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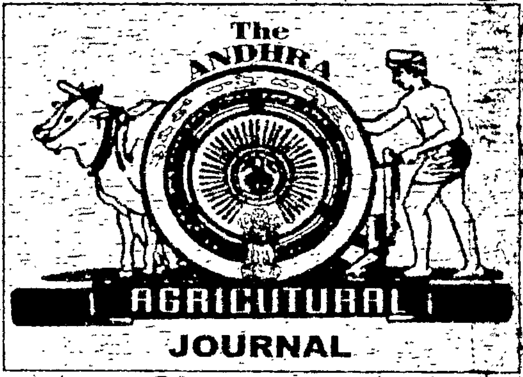

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Effect of Organic Blended Single Superphosphate on Bacterial Population, Soil P Availability, P Uptake and Yield of Rice (*Oryza sativa* L.)

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ABSTRACT

A field experiment was conducted during *kharif* seasons of 2000 and 2001 at Raipur to study the comparative effectiveness of single super phosphate at 50, 75 and 100% recommended dose blended with organics *viz.,* cow dung @ 3t ha^{-1} or poultry manure @ 1.5t ha^{-1} along with PSB on total bacterial populations, and P availability in soil as well as P uptake and yield of rice. The bacterial proliferation was the highest under100% recommended dose of phosphorus (60 kg P_2O_5 ha^{-1}) blended with cow dung + PSB at 40 days after transplanting (DAT), which declined towards maturity of rice. This treatment also registered the highest available P status in soil at 40 DAT and at harvest but was comparable with 100% recommended dose of phosphorus blended with poultry manure + PSB, which showed the highest available P at 80 DAT. The yield of grain (62.24 q ha^{-1}) and straw (84.20 q ha^{-1}) were significantly higher under 100% recommended dose of phosphorus blende with cow dung + PSB but,75% recommended dose of phosphorus blended with cow dung + PSB gave comparable grain yield in 2001. The former treatment recorded 8.7% higher yield over the same level of inorganic P. Significant positive correlation was observed between total bacterial population, available P in soil and grain yield of rice.

key words : Bacterial Population, Organic Blended SSP, PSB, Rice Yield, P Availability

Only a small fraction of phosphatic fertilizers containing water soluble P, is utilized by crop plants, while remaining portion of applied phosphorus becomes fixed in the soil or rendered unavailable to crops (Prakash *et al.*, 1997). The fixation of applied P thus results in low crop recoveries (Singh, 1993). The use of organic matter including biofertilizers helps in improving the biological health of soil, nutrient availability and crop yield (Manna *et al.*, 2001). Therefore, the present investigation was undertaken to study the comparative effectiveness of organic blended single superphosphate on total bacterial population in rhizosphere, P availability, P uptake and yield of rice.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* seasons of 2000 and 2001 at the Instructional farm of Indira Gandhi Agricultural University, Raipur. The soil of the experimental field was sandy loam in texture, neutral in reaction (pH 7.3), low in organic carbon (0.44%) and available N but medium in available P (12.6 kg ha^{-1}). Ten treatments *viz,* no P, 50% recommended P (50% RDP), 50% RDP blended with cow dung + phosphorus solubilizing bacteria (PSB), 50% RDP blended with poultry manure + PSB,75% RDP, 75% RDP blended with cow dung+ PSB, 75% RDP blended with poultry

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Table 1 : Total bacterial population in soil (x10^6/g of soil) at various growth stages of rice as influenced by organic blended single superphosphate

Treatments	40 DAT			80 DAT			At harvest		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
No phosphorus	28.0	29.0	28.5	25.0	24.0	24.5	20.0	20.0	20.0
50% RDP	29.0	30.0	29.5	25.0	26.0	25.5	21.0	23.0	22.0
50% RDP blended with cow dung + PSB	38.0	37.0	37.5	36.0	35.0	35.5	26.0	26.0	26.0
50% RDP blended with poultry manure + PSB	38.0	39.0	38.5	35.0	35.0	35.0	24.0	23.0	23.5
75% RDP	30.0	31.0	30.5	26.0	27.0	26.5	23.0	24.0	23.5
75% RDP blended with cow dung + PSB	42.0	44.0	43.0	40.0	41.0	40.5	29.0	30.0	29.5
75% RDP blended with poultry manure + PSB	40.0	42.0	41.0	39.0	38.0	38.0	27.0	25.0	26.0
100% RDP	32.0	33.0	32.5	28.0	30.0	29.0	24.0	25.0	24.5
100% RDP blended with cow dung + PSB	48.0	50.0	49.0	42.0	45.0	43.5	32.0	34.0	33.0
100% RDP blended with poultry manure + PSB	43.0	45.0	44.0	40.0	42.0	41.0	30.0	31.0	30.5
SEm±	1.0	1.1	0.8	0.9	0.9	0.8	1.2	1.1	1.1
CD (p=0.05)	2.8	3.3	2.3	2.6	2.6	2.3	3.5	3.2	3.2

manure + PSB, 100% RDP blended with cow dung+ PSB, 100% RDP blended with poultry manure + PSB were replicated thrice in a randomized block design. The recommended dose of P was 60 kg P_2O_5 ha^{-1} as single superphosphate, phosphorus solubilizing bacteria@ 2.5 kg ha^{-1} was first mixed with cow dung @ 3 t ha (fresh cow dung decomposed for 14 days) or 1.5 t ha^{-1} of poultry manure and then blended with the required quantity of SSP. This was incubated for 48 hours prior to application at transplanting. The cow dung contained 24.2% C, 0.4% N, 0.25% P, 0.37% K, 83.1% moisture and poultry manure contained 24.2% C, 1.6% N, 0.66% P, 1.0% K, 14.6% moisture. A uniform dose of 100 kg N/ha was applied through urea in three equal splits at transplanting, tillering and panicle initiation stages and 40 kg K_2O ha^{-1} at transplanting through muriate of potash. Rice seedlings *cv.* Mahamaya (125-130 days) were transplanted following inter and intra-row spacing of 20 x 10 cm at an age of 27-29 days. For microbiological studies, soil samples were collected at 40 and 80 days after transplanting and at maturity of rice and preserved in refrigerator in sterilized polythene bags. Bacterial colonies were grown on aspargines mannitol agar media in pertridishes. Bacterial population was computed based on unit weight of dry soil. Simultaneously available P content in soil was also determined as per Olsen (1954). The grain and straw yields of rice were recorded at harvest.

RESULTS AND DISCUSSION

Effect on total bacterial population

There was a significant effect of various approaches of P nourishment to rice on the total

Table 2 : Available P in soil (kg ha^{-1}) at various growth stages of rice as influenced by organic blended single superphosphate

Treatments	40 DAT			80 DAT			At harvest		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
No phosphorus	12.96	13.38	13.17	9.30	9.15	9.23	8.76	9.05	8.91
50% RDP	13.15	13.50	13.33	10.05	10.36	10.21	9.20	9.48	9.34
50% RDP blended with cow dung + PSB	14.66	15.10	14.88	11.36	11.54	11.44	10.78	11.25	11.01
50% RDP blended with poultry manure + PSB	14.00	14.40	14.20	10.82	11.00	10.91	10.30	10.62	10.45
75% RDP	14.25	14.80	14.53	10.94	10.82	10.86	9.72	10.00	9.86
75% RDP blended with cow dung + PSB	20.00	19.60	19.80	15.57	16.10	15.84	14.87	15.30	15.09
75% RDP blended with poultry manure + PSB	18.45	18.50	18.48	14.39	14.56	14.48	13.45	13.85	13.65
100% RDP	16.50	17.00	16.75	12.74	13.14	12.94	11.86	11.74	11.80
100% RDP blended with cow dung + PSB	22.52	21.78	22.15	17.52	16.50	17.01	16.80	17.30	17.05
100% RDP blended with poultry manure + PSB	20.95	19.82	20.39	16.00	17.20	16.60	15.43	16.00	15.72
SEm±	0.58	0.46	0.33	0.41	0.34	0.26	0.29	0.37	0.23
CD (p=0.05)	1.72	1.37	0.99	1.22	1.01	0.77	0.86	1.24	0.67

bacterial population in soil (Table 1). In general, the population was the highest at 40 DAT, which declined with age of the crop. Further, increasing level of inorganic P as well as integration of inorganic P with organics and PSB resulted in higher bacterial count. The highest bacterial population was noticed under 100% RDP blended with cow dung + PSB. At 40 DAT, this treatment was significantly superior to all other treatments but at 80 DAT, it was comparable to 75% RDP blended with cow dung + PSB and 100% RDP blended with poultry manure +PSB in 2000. At harvest, these treatments in 2000 and 100% RDP blended with poultry manure + PSB in 2001 showed similar bacterial count as 100% RDP blended with cow dung + PSB. The decomposition products of organic matter might have stimulated the total bacterial activity, thus increasing their population (Roy *et al.*, 1999). The proliferation of bacterial population was the lowest without P application.

Effect of available P in soil

Available P status in soil at 40 and 80 DAT and at harvest showed a declining trend with advancement in rice growth (Table 2). However, blending with the organic material resulted in increased P availability, which might be due to reduced phosphate absorption with low bonding energy (Sharma and Tripathi, 1999). Further, 100% RDP blended with cow dung + PSB registered the highest available P status in soil, except at 80 DAT in 2001, when 100% RDP blended with poultry manure + PSB resulted in higher P availability although both were at par. Besides, at 40 DAT in 2000 and 80 DAT in pooled data, 100% RDP blended with poultry manure + PSB remained at par with 100% RDP blended with cow dung + PSB. Higher population and efficiency of PSB under the influence of organic matter might have added to P mineralization (Jeyabal and Kuppuswamy, 1999). Blending of fertilizer P with organic manures was capable of reducing P fixation probably due to blocking of fixation sites by organic anions which competed with phosphates for their adsorption on exchange sites and enhanced mineralization of manure P owing to increase solubility of organic P in the presence of fertilizers (Mishra, 1992).

Effect on grain and straw yield

Grain and straw yields of rice were the highest under 100% RDP blended with cow dung + PSB and remained statistically superior to all other treatments (Table 3). However, 75% RDP blended with cow dung + PSB gave comparable grain yield in 2001. Pooled analysis indicated that the former treatment gave 8.7 and 7.1% higher yield over the same level of inorganic P applied either alone or blended with poultry manure along with PSB, respectively. The treatment, 75% RDP blended with cow dung + PSB produced 10.1% higher grain yield over 100% RDP. Such beneficial effect of inorganic P blended with organic and/or bio-organic sources was also reported by Dwivedi and Thakur (2000). This could be possible due to improved physical conditions of soil (Kumar *et al.*, 2001) and higher efficiency of PSB in presence of organic matter (Jeyabal and Kuppuswamy, 1999).

Significant positive correlation was observed between total bacterial population, available P in soil and grain yield of rice. The r values between bacterial population and available P in soil at 40, 80 DAT and harvest were 0.89, 0.88 and 0.96, respectively. During the corresponding periods, the r values between available P in soil and grain yield were 0.67, 0.70 and 0.71. These results are in close agreement with Patil and Varade (1998). Increased bacterial population might have favoured P mineralization, thus increasing the P availability and yield of rice.

P uptake

The total uptake of P due to organic blended single superphosphate was found significant and increased with the increase in levels of P. Further, blending with the organic materials resulted in increased P availability. The highest total P uptake was noticed under 100% RDP blended with cow dung + PSB which was significantly higher than all other treatments. This could be due to more availability of P in soil in agreement with Prakash *et al.*, (1997).

It could be concluded that application of 100% RDP blended with cow dung + PSB resulted in higher bacterial population and P availability in soil and significantly increased the yield and P uptake of rice.

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Influence of Irrigation and Fertility Levels on Growth and Yield of Late Sown Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Two years field study was conducted on sandy loam soils of Indian Agricultural Research Institute, New Delhi during *rabi* seasons of 1992-93 and 1993-94 to find out the effect of irrigation and fertility levels and their interaction on growth and yield of late sown chickpea. Two irrigations scheduled at 0.5 IW/CPE ratio recorded significantly more plant height, number of branches per plant and drymatter production at harvest, while grain yield was significantly high with the application of one irrigation at 0.25 IW/CPE ratio in the first year and in pooled results. Number of pods per plant and seeds per pod were also more with the application of one irrigation. Combined application of phosphorus and sulphur resulted in synergistic action. Higher dose of phosphorus (80 kg P_2O_5 ha^{-1}) combined with sulphur increased growth attributes significantly over lower doses of phosphorus and sulphur. Highest grain yield was recorded with the application of 40 kg P_2O_5 + 40 kg S ha^{-1}.

Key words : Late Sown Chickpea, Phosphorus Levels, Sulphur Levels, Pyrites

Chickpea is the major pulse crop grown in India occupying an area of 7.3 m. ha with a production of 6.2 m.t constituting about 32 per cent of total pulse area and 43.8 per cent of the total pulse production. However, chickpea sowings are delayed due to factors like late harvest of preceding *kharif* crop especially rice and late *kharif* rainfall.

Optimum irrigation schedule is very essential for late sown chickpea as excess soil moisture due to late rains or irrigation causes the plant to revert to vegetative phase even after profuse flowering. Application of phosphorus and sulphur are known to improve the yield and quality especially in legumes. In order to stabilize yields in chickpea, vegetative growth has to be kept under control which can be particularly achieved by late sown technology which involves sowing the crop late by almost a month.

MATERIAL AND METHODS

Two years field studies were carried out to study the influence of irrigation and fertility management on growth and yield of late sown chickpea (*Cicer arietinum* L.) during *rabi* seasons of 1992-93 and 1994-95 on sandy loam soils of Indian Agricultural Research Institute, New Delhi. The experiment was laid out in a spilt plot design with main plots receiving three irrigation schedules and subplots with ten fertility levels and replicated thrice. Three irrigation levels *viz.*, no post-planting irrigation (I_0), irrigation at 0.25 IW/CPE ratio (I_1 one irrigation) at 0.5 IW/CPE ratio (I_2 Two irrigations) were tried in the main plots.

Ten fertility levels in subplots included T_1: control, T_2 : 40 kg P_2O_5 ha^{-1} (DAP), T_3 : 80 kg P_2O_5 ha^{-1} (DAP), T_4 : 40 kg S ha^{-1} (pyrites), Table : Effect of irrigation and fertility levels on growth and yield of late sown chickpea

Treatments	Plant height (cm)		No.of branches per plant		Drymatter accumulation (g/plant)		No.of pods/plant		No.of seeds/pod		Test weight (g)		Grain yield (kg ha^{-1})		Harvest index (%)	
	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94
Irrigation levels																
I_0	40.11	41.26	4.73	4.57	12.71	12.90	23.38	18.95	1.07	1.07	28.02	28.39	800	717	28.89	26.73
I_1	43.46	46.42	4.93	5.17	15.51	16.84	29.12	28.91	1.14	1.16	28.75	29.34	1296	968	32.44	26.21
I_2	47.60	50.68	5.08	5.32	17.04	18.97	28.30	24.71	1.10	1.04	29.29	30.11	913	940	24.30	24.09
SEm±	1.15	0.84	0.06	0.08	0.13	0.09	0.36	0.59	0.01	0.02	0.14	0.13	27	29	0.63	1.10
CD (P=0.05)	4.53	3.31	0.24	0.32	0.49	0.34	1.41	2.32	NS	NS	0.53	0.52	107	113	2.49	NS
Fertility levels																
T_1	39.39	42.06	4.69	4.33	11.93	12.34	19.90	18.69	1.03	1.03	27.89	28.39	833	652	27.23	23.40
T_2	42.88	44.71	4.87	4.91	14.31	16.28	25.33	23.49	1.12	1.10	28.50	29.33	980	848	27.57	24.58
T_3	45.56	48.48	5.07	5.51	15.10	17.64	27.50	24.84	1.09	1.13	28.60	29.44	1015	893	27.43	25.33
T_4	42.94	44.38	4.83	4.87	13.68	15.70	24.97	24.41	1.06	1.05	28.46	29.01	981	835	28.34	25.38
T_5	44.39	46.18	4.87	5.21	14.65	16.56	26.57	24.80	1.11	1.09	28.58	29.23	1013	878	29.01	27.17
T_6	45.27	47.97	4.91	5.10	16.44	17.25	29.53	26.16	1.19	1.12	28.95	29.17	1096	961	30.04	26.53
T_7	46.58	48.81	5.11	5.07	17.58	17.93	30.47	25.75	1.12	1.11	29.32	29.98	1045	967	29.40	28.65
T_8	44.60	47.92	5.04	5.05	17.77	17.31	30.00	25.04	1.07	1.07	28.95	29.48	1031	942	28.68	26.60
T_9	44.69	46.89	4.89	5.61	16.26	16.98	29.69	25.24	1.12	1.15	28.90	29.73	1063	970	28.96	26.48
T_{10}	40.93	43.77	4.84	4.54	13.14	14.37	25.38	23.47	1.12	1.07	28.69	29.05	1008	804	28.78	22.64
SEm±	1.71	0.81	0.12	0.19	0.41	0.41	0.67	1.20	0.04	0.03	0.24	0.26	31	31	0.75	1.07
CD (P=0.05)	4.84	2.31	NS	0.53	1.16	1.15	1.91	3.41	NS	NS	0.69	0.74	87	88	NS	3.02

T_5: 80 kg S ha^{-1} (pyrites), T_6 : 40 kg P_2O_5 ha^{-1} (DAP) + 40 kg S ha^{-1} (pyrites), T_7: 80 kg P_2O_5 ha^{-1} (DAP) + 80 kg S ha^{-1} (pyrites), T_8 : 80 kg P_2O_5 ha^{-1} (DAP) + 40 kg S ha^{-1} (pyrites), T_9: 40 kg P_2O_5 ha^{-1} (DAP) + 80 kg S ha^{-1} (pyrites), T_{10}: 40 kg elemental S ha^{-1}. The gross and net plot sizes were 4 m x 3.6 m and 3.6 m x 3.0 m, respectively.

Phosphorus in the form of DAP was applied in bands about 10-12 cm, below the soil surface, while sulphur in the form of pyrites containing 22% S was broadcasted uniformly as per the treatment one week before sowing. Irrigation was given as and when the cumulative pan evaporation (CPE) reached 120 mm, and 240 mm, in the treatments 0.5 and 0.25 IW/CPE ratios, respectively. The depth of irrigation water applied at each irrigation was fixed at 60 mm.

The soils of the experimental field were uniform in depth up to 60 cm and sandy loam in texture with high moisture retentive capacity with 17.38-17.58% FC and 6.7-6.87% PWP. The soil was medium in available N, low in available P_2O_5 and low in available K_2O with slightly alkaline in reaction.

RESULTS AND DISCUSSION

Effect of irrigation

Two irrigations scheduled at 0.5 IW/CPE ratio resulted in a significant effect on plant height, drymatter and number of branches per plant in both the years due to adequate supply of water in the soil over one irrigation (0.25 IW/CPE) and no irrigation. Bhan and Khan (1982) and Saxena *et al.*, (1990) also reported similar increase in growth parameters with two irrigations.

In contrast to growth characters, yield attributes responded significantly to one irrigation at 0.25 IW/CPE except test weight. The highest number of pods per plant and seeds per pod were recorded with one irrigation scheduled at 0.25 IW/CPE over two irrigations. This indicated that continuous supply of soil moisture status with two irrigations at 0.5 IW/CPE in the soil stimulated excessive vegetative growth and self shading by plants resulted in reduced pod and seed number (Sharma 1994). However, in case of test weight, reverse trend was observed which might be due to better translocation of nutrients with continuous supply of moisture, as also reported by Parihar (1990).

One irrigation at 0.25 IW/CPE yielded significantly higher over other two irrigation levels during the first year. However, both the irrigation levels were statistically on a par during the second year due to excessive rains during peak vegetative phase caused delay in irrigation schedule resulting in reduction in yield with one irrigation. Application of two irrigations significantly increased stalk yield over one irrigation. Conversely the harvest index decreased significantly with two irrigations over one irrigation.

Effect of fertility levels

Application of phosphorus up to 80 kg P_2O_5 ha^{-1} combined with sulphur 80 kg ha^{-1} exhibited the tallest plants in both the years. Highest dry matter production recorded with application of 80 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} in the first year and 80 kg P_2O_5 + 80 kg S ha^{-1} in the second year. Singh and Ram (1990) reported better growth and development of chickpea plants due to the application of 26 kg P and 80 kg S ha^{-1}

Combined application of phosphorus and sulphur had better increase in yield attributes as compared to their individual application. Number of pods per plant and test weight were significantly higher with the application of 80 kg P_2O_5 + 40 kg S ha^{-1}. Combined application of 40 kg P_2O_5 S ha^{-1} and 40 kg S ha^{-1} proved to be the best in increase in grain yield. However, it was on a par with all the P and S combinations where as stalk yield was greater with 80 kg P_2O_5 ha^{-1} in first year and 80 kg P_2O_5 + 80 kg S ha^{-1} in the second year.

Interaction between irrigation and fertility levels was significant with respect to grain yield. Best response was recorded with one irrigation at 40 kg P_2O_5 + 80 kg S ha^{-1}.

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Performance of Direct Seeded Rice as Affected by Variety and Nitrogen Level

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ABSTRACT

Investigations carried out on sandy loam soil at the Agricultural College Farm, Bapatla during *kharif* 2002 to evaluate the effect of variety and nitrogen level on growth and yield of direct seeded rice revealed that the growth and yield parameters were significantly influenced due to varieties and nitrogen levels. The variety Krishnaveni (MTU 2077) showed significant superiority over other varieties *viz.*, Samba Mahsuri (BPT 5204), Surya (BPT 4358) and Swarnamukhi (NLR 145) with respect to growth and yield attributing characters, yield and NPK uptake. There was linear response with increase in N levels from 0 to 120 kg ha^{-1} for all the varieties tested and the highest yield was obtained at the highest nitrogen level, *i.e.* 120 kg ha^{-1}.

Key words : Direct Seeded Rice, Varieties, Nitrogen Levels

In Andhra Pradesh, rice is largely grown in coastal districts which constitutes to about 60 per cent rice production of the state. Whenever, the monsoon is delayed, the farmers are compelled to transplant the crop late in the season with over-aged seedlings due to late release of canal irrigation water. Under these circumstances, farmers are advised to give up transplantation of the crop and to take up direct broadcasting of seed. The direct seeding eliminates nursery preparation, pulling seedlings, hauling and transportation costs, avoids insufficient labour and high wages of transplanting. On the other hand, it provides shorter crop cycle and saves 10 to 15 days of time because of the absence of transplanting shock.

Choice of an appropriate variety for direct seeding under puddle conditions may help in improving the productivity of rice. Among the major plant nutrients, nitrogen continues to be the most important in rice production. Direct seeded rice is very responsive to nitrogen fertilization. Hence, it is inevitable to formulate research strategies for fixing up a suitable nitrogen level for direct seeded rice. The response and uptake of N and crop productivity may vary with genotypes and rate of N application. Keeping this in view, present investigation was carried out to find out a suitable variety and nitrogen level for direct seeded rice.

MATERIAL AND METHODS

A field experiment was conducted during *Kharif* 2002, at the Agricultural College Farm, Bapatla in a randomized block design with factorial concept. The two factors being four varieties of rice *viz.*, Samba Mahsuri (BPT 5204), Krishnaveni (MTU 2077), Surya (BPT 4358) and Swarnamukhi (NLR 145) and four levels of nitrogen 0, 40, 80 and 120 kg ha^{-1}. The soil was sandy loam in texture, slightly alkaline in reaction

Table : Growth and yield attributing characters of direct seeded rice as affected by variety and nitrogen level

Treatments	Drymatter production ($g\ m^{-2}$) at maturity	Productive tillers at maturity (m^{-2})	Total grains $panicle^{-1}$	Filled grains $panicle^{-1}$	1000 grain weight (g)	Grain yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)	Harvest index (%)	N uptake at maturity ($kg\ ha^{-1}$)	Benefit Cost Ratio
Variety (V)										
Samba Mahsuri	959.1	288.8	106.7	94.6	14.9	3588	4994	41.4	70.0	2.98
Krishnaveni	1116.0	315.3	132.5	104.8	20.1	4310	5338	44.5	88.2	2.40
Surya	983.0	297.8	115.9	100.1	21.8	3838	5056	42.6	76.8	2.56
Swarnamukhi	1039.3	304.3	100.3	89.8	23.7	4196	5211	44.4	83.0	2.16
SEm±	28.1	6.3	3.7	3.1	0.5	125	90	0.7	2.6	
CD (0.05)	81.3	18.2	10.7	9.1	1.3	360	260	2.1	7.4	
Nitrogen level (N) ($kg\ ha^{-1}$)										
0	819.0	248.5	94.5	79.2	17.2	3027	4312	41.0	52.6	2.05
40	939.0	288.3	106.6	88.3	18.9	3669	4737	43.4	69.8	2.37
80	1103.0	320.3	116.4	101.5	21.0	4277	5410	44.0	87.9	2.67
120	1236.0	349.0	137.8	120.3	23.4	4958	6141	44.5	107.8	2.96
SEm±	28.1	6.3	3.7	3.1	0.5	125	90	0.7	2.6	
CD (0.05)	81.3	18.2	10.7	9.1	1.3	360	260	2.1	7.4	
V x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	
CV (%)	9.5	7.2	11.2	11.2	7.8	10.9	6.0	5.7	11.2	

NS : Non-significant

(p^H 8.4), low in organic carbon (0.27%) and available nitrogen (165.85 kg ha^{-1}), medium in available phosphorus (19.65 kg ha^{-1}) and high in available potassium (391.00 kg ha^{-1}). Sprouted seed was broadcasted in the levelled plots with a thin film of water, using a seed rate of 100 kg ha^{-1} . Nitrogen was applied as per treatments in three splits *viz.*, 1/2 as basal, 1/4 at active tillering and 1/4 at panicle initiation in the form of urea. Entire quantity of recommended dose of phosphorus @ 60 kg P_2O_5 ha^{-1} and potassium @ 40 kg K_2O ha^{-1} was applied uniformly to all the plots as basal in the form of single superphosphate and muriate of potash, respectively. Recommended agronomic practices and plant protection measures were followed. Pre and post-harvest observations in respect of both growth and yield parameters were recorded following standard practices. Similarly chemical analysis for N, P and K uptake was done by NP Analyser Skalar methods and flame photometric method, respectively.

RESULTS AND DISCUSSION

The results indicated that the growth parameters such as plant height, drymatter production, days to 50 per cent flowering, days to maturity, yield attributes *viz.*, productive tillers, total and filled grains panicle^{-1}, thousand grain weight and NPK uptake were significantly influenced due to varieties and nitrogen levels (Table 1). However, their interaction effect was non-significant.

Effect of variety

The maximum drymatter production (1116 g m^{-2}), productive tillers m^{-2} (315.3), total and filled grains panicle $^{-1}$ (132.5 and 104.8 respectively), grain yield (4310 kg ha^{-1}), straw yield (5338 kg ha^{-1}), harvest index (44.5%) and NPK uptake were recorded with Krishnaveni (Table 1). The difference in these characters with different varieties could be attributed to the genetic make up of the varieties. Eventhough, the number of filled grains were less (89.8) for Swarnamukhi, its higher test weight (23.7 g) might have compensated for the less grain number and stood second in respect of yield over and above Surya and Samba Mahsuri. Similar results with different varieties were noticed earlier by Channabasavanna and Setty (1992) and Muthukrishnan *et al.*, (1997). Higher NPK uptake by Krishnaveni might be because of its high adaptability to heavy fertilization, compared to others. Present results were in tune with findings of Bhattacharyya and Singh (1992). Though the lowest grain yield was recorded with Samba Mahsuri (Table 1) it fetched greater price with its super fine grain quality and demand in the market, thereby the highest (2.98) benefit cost ratio. Singh *et al.*, (1999) reported similar results on economics of different varieties under puddled irrigated conditions.

Effect of nitrogen level

The growth, yield and attributing characters, yield and NPK uptake were the maximum with 120kg N ha^{-1} which was significantly superior over the levels (Table1). This increased growth might be due to enhanced cell division and cell elongation induced by abundant nitrogen supply with increasing nitrogen level, favouring higher production of green leaves with increased chlorophyll content, enabling plants to have increased photosynthetic efficiency. Yoshida (1981) also reported a linear increase in tillering of rice with increased concentration of N upto 5 per cent. Abundant supply of nitrogen at higher levels might have resulted in stronger and study tillers and consequent early flowering and maturity. These results confirm the findings of Chandramani (1999). At higher N dose, the root surface area might have increased, increasing P and K uptake, thereby resulting in good grain filling. The increased grain and straw yields with increased N level were attributed to significant improvement in yield and growth characters as was reported by Prasad *et al.*, (1992). The maximum NPK uptake noticed at 120 kg N ha^{-1} which is apparent from grain and straw yields at this level might be due to combined effect of increased nutrient concentration and higher drymatter accumulation. Application of nitrogen increases the root cation exchange capacity and surface area enhancing NPK absorption and the increased absorption of N increases leaf area, photosynthetic rate and ultimately results in more bio-mass production. Similar results on NPK uptake were also reported by Deepa Thomas and James Martin (1999). The highest benefit cost ratio (2.96) was obtained at 120 kg N ha^{-1} which was due to the highest grain (4958 kg ha^{-1}) and straw yields (6141 kg ha^{-1}) at this level.

Response function

Under direct seeded condition, among the tested varieties and nitrogen levels, quantitatively Krishnaveni and economically Samba Mahsuri proved to be suitable for direct seeded conditions, while the highest grain and straw yields and benefit cost ratio were obtained with 120 kg N ha^{-1}.

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Effect of Combined Application of Nutrients and Hormones on Growth and Yield of Blackgram (*Phaseolus mungo* L.)

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ABSTRACT

The influence of combined foliar application of nutrients and hormones on growth and yield of blackgram has been studied at Agricultural College and Research Institute, Madurai during *rabi* 2003. The nutrients *viz*.. DAP, KCl and growth hormone NAA were applied along with different nutrients like Zn and Mg. Application of DAP 2 per cent + $ZnSO_4$ @ 0.25 per cent + $MgSO_4$ @ 0.5 per cent + NAA 40 ppm significantly increased leaf area index, crop growth rate. relative growth rate and net assimilation rate which in turn enhanced yield attributes and yield of blackgram.

Key words : Blackgram, Foliar Nutrition, Naphthalene Acetic Acid, Growth, Yield

Legumes are widely recognized to be an impressive symbol of agricultural economy, being a major source of protein in vegeterian diet and also improving the soil fertility through their nitrogen fixing capability (Upadhyay, 2002). In India, pulse crops are grown on an area of 23 m ha accounting for nearly 33 per cent of world acreage and consumed by 22 per cent of world's population (Singhal, 1999). Blackgram, one of the most favourable pulse crops of South India recorded low productivity. The causes for low yield are a number of physoilogical, biochemical as well as certain inherent factors associated with the crop. Apart from genetic constitution, the physiological factors such as poor photosynthetic efficiency, inefficient partitioning of assimilates, poor pod setting, excessive flower abscission and lack of nutrients during the critical stages of the crop growth were found to be some of the yield barriers of blackgram (Promila Kumari and Varma, 1983).

Of the several approaches to overcome the problem, role of exogenous application of nutrients and growth regulating substances in increasing growth, flowering, pod filling and grain yiled assume importance. The effect of foliar application of phosphorus on dry matter and seed yield of blackgram was studied by Yakadri and Ramesh (2000). Application of NAA of 50 ppm increased the growth parameters like LAI, LAD, NAR and total dry matter poduction of berseem (Garg *et al.*, 1990). Hence, the present investigation was carried out to study the influence of combined application of nutrients and hormones on growth and yield of blackgram.

MATERIAL AND METHODS

A field experiment was conducted during *rabi* season of 2003 at Agricultural College and Research Institute, Madurai using blackgram variety Vamban 4. The soil of the experimental filed was sandy clay loam in texture, classified as low in available nitrogen and medium in available P_2O_5 and K_2O contents with neutral reaction. The treatments comprised T_1 : water spray, T_2 : DAP 2 per cent, T_3 : KCl 1 per cent, T_4 : DAP 2 per cent + $ZnSO_4$ @ 0.25 per cent,

Table 1 : Effect of combined foliar application of nutrients and hormones on growth parameters of blackgram

Treatments	LAI	Crop growth rate (g m^{-1} d^{-1}) (45 DAS to harvest)	Relative growth rate (g m^{-1} d^{-1}) (45 DAS to harvest)	Net assimilation rate (g m^{-1} d^{-1}) (45 DAS to harvest)	Number of root nodules per plant
T_1 Water spray	2.405	1.999	23.58	0.131	26.68
T_2 DAP 2%	2.665	2.067	23.95	0.141	32.50
T_3 KCl 1%	2.538	2.037	23.76	0.137	30.25
T_4 DAP 2%+ZnSO$_4$ @ 0.25%	2.924	2.121	24.31	0.150	37.44
T_5 KCl 1%+ZnSO$_4$ @ 0.25%	2.790	2.096	24.15	0.146	34.00
T_6 DAP 2%+ZnSO$_4$@0.25%+MgSO$_4$ @0.5%	3.302	2.206	24.85	0.161	38.65
T_7 KCl 1%+ZnSO$_4$@0.25%+MgSO$_4$ @0.5%	3.050	2.152	24.50	0.155	35.20
T_8 DAP 2%+ZnSO$_4$@0.25%+MgSO$_4$ @0.5% + NAA 40 ppm	3.681	2.368	25.10	0.167	40.15
T_9 KCl 1%+ZnSO$_4$@0.25%+MgSO$_4$ @0.5% + NAA 40 ppm	3.180	2.184	24.70	0.159	37.60
CD (P = 0.05)	0.125	0.024	0.16	0.004	1.25

T_5: KCl 1 per cent + ZnSO$_4$ @ 0.25 per cent, T_6: DAP 2 per cent + ZnSO$_4$ @0.25 per cent + MgSO$_4$ @ 0.5 per cent, T_7: KCl 1 per cent + ZnSO$_4$ @ 0.25 per cent + MgSO$_4$ @ 0.5 per cent, T_8: DAP 2 per cent + ZnSO$_4$ @ 0.25 per cent + MgSO$_4$ @ 0.5 per cent + NAA 40 ppm, T_9: KCl 1 per cent + ZnSO$_4$ @ 0.25 per cent + MgSO$_4$ @ 0.5 per cent + NAA 40 ppm. The treatments were evaluated in randomized block design replicated thrice. Blackgram was sown by adopting an inter- and intra-row spacing of 30 cm x 10 cm. The first spray was taken up at 50 per cent flowering followed by a second spray a fortnight after first spray. For foliar spraying, 500 litres ha^{-1} of spray fluid was applied with knapsack sprayer. The recommended dose of 25 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1} was applied uniformly to all plots. The growth parameters like LAI, nodulation, crop growth rate, relative growth rate and net assimilation rate were estimated at 45 DAS and at harvest.The yield and yield parameters were recorded at the stage of maturity.

RESULTS AND DISCUSSION

Effect on growth parameters

Foliar application of nutrients along with hormones significantly influenced all the growth parameters (Table 1). Application of DAP 2 per cent + ZnSO$_4$ @ 0.25 per cent + MgSO$_4$ @0.5 per cent + NAA 40 ppm (T_8) recorded the highest leaf area index (3.681), crop growth rate (2.368 g m^{-2} d^{-1}), relative growth rate (25.10 mg g^{-1} d^{-1}) and net assimilation rate (0.167 mg cm^{-2} d^{-1}). This was followed by the application of DAP 2 per cent + ZnSO$_4$ @0.25 per cent + MgSO$_4$ @0.5 per cent (T_6) which was comparable with the application of KCl 1 per cent + ZnSO$_4$ @ 0.25 per cent + MgSO$_4$ @ 0.5 per cent + NAA 40 ppm (T_9). This clearly showed the beneficial effect of foliar spraying of NAA in combination with other nutrients on growth parameters of blackgram. Similar findings were recorded in soybean by Dhope and Suradkar (1998). The control plot recorded the lowest values of all growth parameters. The foliar application of

Table 2 : Effect of combined foliar application of nutrients and hormones on yield attributes and yield of blackgram

Treatments	Number of clusters plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Grain yield (kg ha^{-1})
T_1 Water spray	8.88	11.90	5.02	4.40	658
T_2 DAP 2%	10.68	16.07	5.56	4.54	772
T_3 KCl 1%	10.11	14.37	5.38	4.48	737
T_4 DAP 2%+$ZnSO_4$ @ 0.25%	11.84	18.10	5.76	4.62	825
T_5 KCl 1%+$ZnSO_4$ @ 0.25%	11.26	17.57	5.60	4.55	790
T_6 DAP 2%+$ZnSO_4$@0.25%+$MgSO_4$ @0.5%	13.25	21.23	5.81	4.66	933
T_7 KCl 1%+$ZnSO_4$@0.25%+$MgSO_4$ @0.5%982	12.43	19.00	5.64	4.58	873
T_8 DAP 2%+$ZnSO_4$@0.25%+$MgSO_4$ @0.5% + NAA 40 ppm	13.87	23.33	5.97	4.73	982
T_9 KCl 1%+$ZnSO_4$@0.25%+$MgSO_4$ @0.5% + NAA 40 ppm	13.00	21.00	5.80	4.64	913
CD (P = 0.05)	0.57	0.53	0.16	0.06	32

nutrients with DAP recorded significantly higher values of all growth parameters than with KCl. Application of DAP 2 per cent + $ZnSO_4$ @ 0.25 per cent + $MgSO_4$ @ 0.5 per cent + NAA 40 ppm (T_8) recorded significantly higher number of root nodules plant^{-1} (40.15). This might be due to increased activity of rihzobia in the soil due to iincreased chlorophyll contents in leaves, there by increasing photosynthetic efficiency. This might have led to provide more assimilates for better nodulation (Sivasankar *et al.*, 1984).

Effect on yield attributes and yield

The combined application of DAP 2 per cent + $ZnSO_4$ @ 0.25 per cent + $MgSO_4$ @ 0.5 per cent + NAA 40 ppm (T_8) recorded signiicantly hgiher number of clusters per plant (13.87), pods per plant (23.33), seeds per pod (5.97) and test weight (4..73 g) (Table 2). This was followed by the application of DAP 2 per cent + $ZnSO_4$ @ 0.25 per cent + $MgSO_4$ @0.5 per cent (T_6). The increased grain yield (982 kg ha^{-1}) was recorded with the application of DAP2 per cent + $ZnSO_4$ @ 0.25 per cent + $MgSO_4$ @ 0.5 per cent + NAA 40 ppm (T_8). Thus all the yield attributes which directly contribute towards grain yield significantly influenced by the combined application of DAP 2 per cent + $ZnSO_4$ @ 0.25 per cent + $MgSO_4$ @ 0.5 per cent + NAA 40 ppm (T_8) sprayed at two stages of crop growth. The grain yield was greatly influenced by the above promising combination of nutrients and hormones. This is in accordance with the findings of Kalita *et al.*, (1995). They reported that the application of NAA might have induced large number of new sinks leading to the greater activity of carboxylating enzymes and rate of protein synthesis. This resulted in higher photosynthetic rate and translocation and accumulation of metabolites in the sink and eventually greater seed production per untit area (Shukla *et al.*, 1997). Blackgram, though produces more number of flowers, most of them get abscised without forming pods. The retention of flowers and pods in the plant can be increased by the combined application of nutrients and plant growth regulators (NAA) as reported by Sharma and Dey (1986) in soybean.

Combined application of nutrients with NAA was found to have a positive effect on growth and yield of blackgram. The foliar sprays of nutrients along with hormones is necessary to narrow down the yield gap in blackgram. It can be concluded that for obtaining higher grain yield, blackgram can be sprayed with the combination of DAP 2 per cent + $ZnSO_4$ @ 0.25 per cent + $MgSO_4$ @ 0.5 per cent + NAA 40 ppm (T_8) at 50 per cent flowering and a fortnight after first spray.

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In-situ Moisture Conservation and Yield of Rainfed Groundnut (*Arachis hypogaea* L.) as Influenced by Moisture Conservation Practices and Nutrient Management

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ABSTRACT

An experiment was conducted during *kharif* 1999 and 2000 to study the influence of different moisture conservation practices and nutrient management on in-situ moisture conservation and yield of rainfed groundnut. Moisture conservation practices involving alternate furrow and bed followed by ridges and furrows registered higher moisture content at 0-15 cm and 15-30 cm depth at all stages of crop growth over flat bed method. Similarly the same treatments recorded significantly higher pod and haulm yields as well as rainfall use efficiency. Plastic mulch and straw mulch also recorded similar positive results in terms of soil moisture content, pod and haulm yield and rainfall use efficiency as was observed in case of land configurations. 100% RDF + IBA @ 50ppm + Urea @ 1% at 40 and 60 DAS (N_3) followed by 100% RDF (N_2) resulted in significantly higher pod, haulm yield and also rainfall use efficiency as compared to control (N_0).

Key words : Moisture Conservation, Rainfed Groundnut, Nutrient Management

About 87.7 per cent of groundnut area in India is sown in *kharif* season and is rainfed (Bandyopadhyay *et al.*, 2000). The region of Saurashtra in Gujarat is being highly influenced by the vagaries of monsoon besides inadequate moisture supply and poor fertility status of the soil that results in partial or total failure of crop with occurrence of mild to severe drought.

The cheapest and most efficient method of conserving rainwater is to hold in-situ. Land configurations and use of mulches are appropriate measures to conserve rainwater and sustain crop production (Singh and Das, 1988). In Gujarat, especially in the region of Saurashtra the work done on the effect of moisture conservation practices alone and in combination with integrated nutrient management is very meagre. Therefore, present investigation was carried out for stabilizing and stepping up of groundnut yields in Gujarat.

MATERIAL AND METHODS

An experiment was conducted at the Instructional Farm, Gujarat Agricultural University, Junagadh during *kharif* 1999 and 2000. The soils were clayey in texture, slightly alkaline in reaction and low in phosphorus. Thirty-six treatment combinations in total were evaluated in a split plot design with three replications taking combination of three levels of land configurations (L_0 = Flatbed, L_1 = Ridges and furrows, L_2 = Alternate furrows and Beds) and mulches (M_0 = Control, M_1 = Wheat straw @ 5 t/ha and M_2 = Plastic mulch of 8μ) as main treatments and four levels of nutrient management (N_0 = Control, N_1 = Recommended dose of fertilizer (RDF) *i.e.*, 12.5 N + 25.0 P_2O_5 kg/ha, N_2 = 50% RDF + 5 t FYM + Rhizobium+

Table : Effect of different treatments on soil moisture (%) (Oven dry weight basis) during crop growth, rainfall use efficiency and yield of *kharif* groundnut

	Average moisture status (%) of soil over different stages (30 days to harvest)*				Pod yield (kg ha^{-1})			Haulm yield (kg ha^{-1})			Rainfall efficiency (kg ha^{-1} mm^{-1})*		
	0-15 cm		15-30 cm										
Land Configuration	1999	2000	1999	2000	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Mean
L_0 = Flat bed	18.61	19.01	19.15	19.28	1246	1606	1426	1889	2416	2152	4.04	3.77	3.91
L_1 = Ridges & Furrows	21.18	21.69	21.65	22.01	1387	1800	1594	2046	2621	2333	4.50	4.23	4.37
L_2 = Alternate Furrow & Bed	21.64	21.96	21.94	22.22	1463	1866	1665	2170	2727	2449	4.74	4.38	4.56
SEm±	-	-	-	-	30.88	34.45	23.13	46.90	52.19	35.08	-	-	-
CD (P=0.05)	-	-	-	-	92.61	103.29	66.67	140.60	156.48	101.11	-	-	-
Mulches (M)													
M_0 = Control	18.61	19.11	19.26	19.37	1280	1649	1464	1908	2425	2167	4.15	3.87	4.01
M_1 = Wheat straw @ 5 t ha^{-1}	21.33	21.68	21.67	21.97	1419	1830	1624	2118	2698	2408	4.60	4.30	4.45
M_2 = Plastic mulch 8 u	21.44	21.80	21.93	22.18	1398	1794	1596	2079	2641	2360	4.53	4.21	4.37
SEM ±	-	-	-	-	30.88	34.45	23.13	46.90	52.19	35.08	-	-	-
CD (P=0.05)	-	-	-	-	92.61	92.61	66.67	140.60	156.48	101.11	-	-	-
Nutrient Management													
N_0 = Control	21.64	21.83	21.91	22.19	1147	1446	1297	1795	2261	2028	3.72	3.39	3.56
N_1 = 100% RDF (12.5 N + 25.0 P_2O_5 Kg ha^{-1})	20.19	20.43	20.69	20.81	1416	1847	1631	2082	2669	2376	4.59	4.34	4.47
N_2 = 50% RDF + 5 t FYM + Rhizobium + PSM	20.60	20.75	20.91	21.18	1392	1796	1594	2067	2640	2353	4.51	4.22	4.37
N_3 = 100% RDF + IBA @ 50 ppm+ Urea 1% spray at 40 & 60 DAS	19.98	20.13	20.36	20.85	1507	1941	1724	2196	2782	2489	4.88	4.56	4.72
SEm±	-	-	-	-	34.69	36.92	25.33	40.90	55.54	34.49	-	-	-
CD (P=0.05)	-	-	-	-	94.40	104.72	71.08	116.03	157.54	96.78	-	-	-

*Data statistically not analyzed

Phosphorus solubulizing mycorrhiza (PSM), N_3 = 100% RDF + Indole Butyric Acid (IBA) @ 50ppm + Urea@ 1% at 40 and 60 days after sowing (DAS). Semi spreading variety GG-20 was sown at inter- and intra-row spacing of 60x10 cm as sub treatment (Table 1).

The land configurations and mulches were applied as per the treatments at 20 days after sowing. The mulch materials were adjusted and rearranged as and when needed especially after disturbance due to rainfall. The soil moisture status studies at 0-15 cm and 15-30 cm depth were carried out at 15 days interval starting from 30 DAS. The soil samples were analyzed thermogravimetrically for moisture content and are expressed in terms of percentage on oven dry weight basis. The rainfall use efficiency was calculated by the effective rainfall utilized by the crop.

RESULTS AND DISCUSSION

Effect of moisture conservation practices

The two years data indicates that the moisture conservation practices involving modified land configurations and mulches had marked effect on moisture content in the soil, pod and haulm yield (Table 1). Alternate furrow and bed resulted in higher average moisture per cent *i.e.,* 21.64 and 21.96 at 0-15 cm depth and 21.94 and 22.22 per cent at 15-30 cm depth in 1999 and 2000, respectively over different periods (30 DAS to harvest) while flat bed resulted in lower soil moisture content.

Further, the above treatment also registered significantly higher pod (1665 kg/ha) and haulm (2449 kg/ha) yields in pooled results and higher mean rainfall use efficiency (4.56 kg ha^{-1} mm^{-1}) over flat bed method. The ridges and furrows also registered the same positive results as was observed in case of alternate furrow and bed. The modified land configurations might have provided friable, soft seedbed and improved physical environment with in the zone that resulted in higher infiltration of rain water there by improving the moisture status of the soil, which ultimately favoured the plant growth, yield attributes and there by yield. Owing to the higher pod yield with modified land configurations, rainfall use efficiency was higher. Higher water use efficiency with modified land configurations over flatbed was also reported by Chavan *et al.*, (1999), while Venkateswarlu (1999) registered higher rainfall use efficiency with broad bed and furrows and ridges and furrows over flatbed method.

Both plastic and wheat straw mulches had a pronounced influence on soil moisture status resulting in high values for soil moisture status in both years as compared to control at different stages of crop growth, Plastic mulch retained more average soil moisture (21.44 and 21.80 at 0-15 cm and 21.93 and 22.18 per cent at 15-30 cm soil depth in 1999 and 2000 respectively) followed by wheat straw mulch. Further, wheat straw produced the maximum pod yield (1624 kg ha^{-1}) and was at par with plastic mulch and significantly superior over control. Haulm yield also followed same trend as was observed with pod yield. Owing to the higher pod and haulm yield, the rainfall use efficiency was also higher with both mulches over control. The higher soil moisture content with mulches could be attributed to the increased downward movement of rainwater, reduced weed growth, evaporation and wide fluctuations in diurnal soil temperatures as compared to no mulching (Control) where less moisture was stored due to more evaporation(Gupta and Gupta, 1986). Higher moisture content with mulches was also reported by Khistaria *et al.*, (1994) and Shinde *et al.*, (2000). The favourable effect of plastic and wheat straw mulches in terms of growth and pod and haulm yield could be attributed to their beneficial effects on growth parameters, yield attributes due to increased moisture content in the root zone coupled with availability of more nutrients. The results are in conformity with Khistaria *et al.*, (1994) and Basu (1999).

Effect of nutrient management

100 % RDF + IBA @ 50 ppm + Urea @ 1% at 40 and 60 DAS (N_3) recorded higher pod (1724 kg ha^{-1}) and haulm (2489 kg ha^{-1}) yield and it was at par with 100 % RDF (N_1) in individual years and significantly superior over control (N_0). The per cent increase in pod yield with N_3 and N_1 over control was 39.92 and 25.75, respectively in pooled results. Further, N_3 resulted in higher mean rainfall use efficiency (4.72 kg ha^{-1} mm^{-1}) followed by N_1 and N_2 as compared to control N_1.

The nutrient management treatments (N_3, N_2, N_1) helped to increase the availability of nutrients in the soil, where the available nutrients coupled with adequate moisture helped the plants to put forth optimum plant growth and development with proliferate root system, thereby absorption of more moisture, which ultimately resulted in optimum plant growth there by higher pod and haulm yield and hence the higher rainfall use efficiency. It was also reported by Arnon and Gupta (1975) that the water use efficiency and also crop yields can be increased by the adoption of efficient management practices like optimum utilization of fertilizers. The amount and distribution of rainfall was good in 2000(529.8 mm) as compared to 1999 (394.5 mm), hence the growth, yield attributes and yield level were better in 2000.

From the above results, it is evident that modified land configurations like alternate furrow and bed and ridges and furrows with either plastic or wheat straw mulch and 100% RDF was found to be effective in increasing soil moisture content leading to higher productivity in rainfed groundnut.

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Use of FYM and Phosphorus on Yield, Economics and Nutrient Uptake in Chickpea (*Cicer arietinum* Linn.)

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ABSTRACT

A field experiment on chickpea tested under different levels of FYM and phosphorus during *rabi* season at the Agricultural College Farm, Bapatla indicated that FYM could significantly increase the chickpea haulm yield only. Further, FYM Levels significantly increased the NPK uptake by chickpea but with low monetary returns. Phosphorus application upto 60 kg P_2O_5 ha^{-1} resulted in higher yields, nutrient uptake and monetary returns and was statistically comparable with 90 kg P_2O_5 ha^{-1}.

Key Words: Chickpea, FYM Levels, Monetary Returns, Nutrient Uptake, Phosphorus Levels, Yield

Chickpea is the most popular pulse crop of India and cultivated over an area of 7.54 million hectares with a production of 6.13 million tonnes. In Andhra Pradesh chickpea occupies an area of 4.22 lakh hectares with an annual production of 4.57 lakh tonnes (Economics and Statistical Bulletin, 2004). The average productivity of chickpea is 812 and 1082 kg in India and Andhra Pradesh, respectively. One of the important reasons for this lower productivity is the low fertility status of the rainfed soils on which this crop is mostly cultivated. Hence, there is good scope to increase the productivity of chickpea by proper nutrient management particularly the phosphorus management.

Application of FYM is known to meet the nutrient requirement of crop and also to improve the physical properties of soil such as soil structure and moisture holding capacity (Venkateswarlu, 2000). Farm yard manure increases the absorptive power of soil for cations and anions particularly phosphates and nitrates. These absorbed ions are released slowly for the benefit of crop during the entire growth period and thus there is a possibility of increasing the concentration and uptake of these nutrients by plants with the use of farm yard manure. Increased yield with phosphorus application might be due to its adequate supply resulting in enhanced carbohydrate synthesis and rate of metabolic activities through increased leaf area and its efficient utilization of protein synthesis resulting in bolder grains. Phosphorus application increases the uptake of nutrients due to the effect of phosphorus in utilizing larger quantities of nutrients through well developed root system leading to better plant development.

MATERIAL AND METHODS

A field experiment was conducted on clay loam soils of Agricultural College Farm, Bapatla during *rabi* of 2001. Experimental soil was clay-loam in texture, medium in total nitrogen (283 kg ha^{-1}), low in available phosphorus (24 kg ha^{-1}), high in available potassium (710 kg ha^{-1}) and slightly alkaline in reaction (pH 8.1) with normal electrical conductivity (0.6 dSm^{-1}). The

Table 1 : Effect of different treatments on drymatter accumulation (g/m²), seed yield (kg ha⁻¹), haulm yield (kg ha⁻¹) and economics of chickpea

Treatments	Drymatter accumulation (g/m²)	Seed yield (kg ha⁻¹)	Haulm yield (kg ha⁻¹)	Net returns (Rs. ha⁻¹)	Benfit cost ratio
FYM (t ha⁻¹)					
0	296	1351	2190	13710	1.03
5	339	1373	2362	13680	0.99
10	390	1393	2497	12565	0.82
CD at 5%	30.2	NS	98		
Phosphorus (kg P_2O_5 ha⁻¹)					
0	289	1048	2150	7583	0.56
30	332	1359	2279	13526	0.99
60	375	1538	2471	16836	1.20
90	389	1544	2498	16660	1.17
CD at 5%	34.8	85.0	113		

treatments consisted of 3 levels of FYM (0, 5 and 10 t ha⁻¹) and 4 levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha⁻¹) laid in randomized block design with factorial concept and replicated thrice.

RESULTS AND DISCUSSION

Role of FYM on yield and economics

All the FYM levels could equally influence the seed yield of chickpea crop (Table 1). The crop was sown during the last week of November and was subjected to moisture stress at flowering and pod formation stages. This moisture stress at the critical stages caused the failure of the flowers to develop into pods. Raju and Varma (1984) opined that application of FYM did not significantly affect the grain yield of chickpea.

FYM levels tried significantly influenced the haulm yield (Table 1). Application of 10 t FYM ha⁻¹ registered the highest haulm yield of 2497 kg ha⁻¹ followed by 5 t FYM ha⁻¹ which registered 2362 kg haulm yield ha⁻¹. Favourable soil moisture environment and better soil physical properties might have lead to production of higher haulm yield. The results of the present investigation are in agreement with that of Navale and Gaikwad (1998) in soybean.

Application of FYM (5 or 10 t ha⁻¹) has resulted in lower net returns. The lowest net returns and benefit cost ratio were registered by the application of 10 t FYM ha⁻¹ and was followed by 5 t FYM ha⁻¹ . The cost involved in the purchase, transport and application of FYM might be the reason for these results.

Role of phosphorus on yield and economics

Phosphorus had a significant influence on seed and haulm yield of chickpea crop (Table 1). The data revealed that application of P_2O_5 upto 60 kg ha⁻¹ registered higher seed yield (1538 kg ha⁻¹) which was on a par with 90 kg P_2O_5 ha⁻¹ (1544 kg ha⁻¹), and same was observed for haulm yield. Borgohain and Agarwal (1986) opined that the increased yields of chickpea with phosphorus application might be due to its adequate availability resulting in enhanced carbohydrate synthesis and rate of metabolic activities through increased leaf area, dry matter accumulation and its efficient utilization in protein synthesis resulting in bolder grains and high haulm yields, in conformity with Gupta *et al*., (1998).

Table 2 : Nutrient uptake of chickpea (kg ha^{-1}) as influenced by FYM and Phosphorus levels.

Treatments	Nutrient Uptake (kg ha^{-1}) N	P	K
FYM (t ha^{-1})			
0	49.0	7.56	50.0
5	55.8	9.93	56.1
10	62.2	11.30	63.4
CD at 5%	5.6	0.8	5.8
Phosphorus (kg P_2O_5 ha^{-1})			
0	47.4	6.9	49.1
30	54.9	9.1	56.8
60	63.4	12.2	64.7
90	64.2	12.4	65.5
CD at 5%	6.5	1.0	6.8

Phosphorus application @ 60 kg ha^{-1} produced the highest net returns of Rs. 16,836 ha^{-1} (Table 1) with a benefit cost ratio of 1.20. This could be due to increased seed yield with phosphorus application, as reported by Joseph *et al.*, (1997).

Role of FYM on nutrient uptake

Application of FYM significantly influenced the N, P and K uptake (Table 2). The data indicated that with increase in the level of FYM from 0 to 10 FYM ha^{-1} there was a significant increase in nutrient uptake and maximum N, P and K uptake was observed with 10 t FYM ha^{-1}. The highest N uptake (62.2 kg ha^{-1}), P uptake (11.30 kg ha^{-1}) and K uptake (63.4 kg ha^{-1}) was registered by applying 10 t FYM ha^{-1} whereas the lowest values of N uptake (49.0 kg ha^{-1}), P uptake(7.56 kg ha^{-1}) and K uptake (50.0 kg ha^{-1}) were observed with 0 t of FYM ha^{-1}. It appears that organic acids produced from organic substances may partly be responsible for quick release of nutrients which resulted into more uptake of nutrients, in conformity with Raju *et al.*, (1991).

Role of phosphorus on nutrient uptake

Different levels of phosphorus tried could significantly influence the N, P and K uptake by chickpea crop. With each increment in phosphorus level, there was a significant increase in the nutrient uptake upto 60 kg P_2O_5 ha^{-1}. Further increase in phosphorus level could not increase the nutrient uptake significantly. The highest N, P and K uptake of 64.2, 12.4 and 65.5 kg ha^{-1}, respectively was registered in 90 kg P_2O_5 ha^{-1}. However, this was statistically comparable with 60 kg P_2O_5 ha^{-1}. Both these levels were significantly superior to the rest of the treatments tested. Higher yields (Table 1) associated with these treatments might be due to higher nutrient uptake, in line with Acharya *et al.*, (1991) and Jat and Mali (1992).

The results of this experiment indicate that to register higher yields, monetary returns associated with higher nutrient uptake in chickpea, it is required to apply P_2O_5 upto 60 kg ha^{-1}. However, applying FYM at 5 or 10 t result in lower monetary returns due to the cost involved in purchase, transport and application of FYM to chickpea crop.

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Compatibility of Medium Duration Redgram with Short Duration Redgram and Blackgram in Intercropping System

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ABSTRACT

Field study on compatibility and profitability of intercropping revealed that medium duration redgram (Abhaya) with blackgram (LBG 20) or with short duration redgram (Jagriti) was found to have an effect on yield attributes and yield. Highest yield was obtained with sole crop of Abhaya and it was closely followed by Abhaya + blackgram system at 1:2 row proportion. Maximum pigeonpea equivalent yields, monetary advantage and higher LER were recorded and showed that Abhaya can be successfully grown with blackgram.

Key Words: Intercropping, Compatibility, Profitability, Redgram, Blackgram, LER, Pigeonpea Equivalent Yields, Monetary Advantage

Pulses occupy unique place in Indian agriculture. These are rich sources of protein in vegetarian diet. In India, during the past four decades the area, production and productivity of pulse have virtually remained stagnant. There is little scope for increasing the area with the present system of crop production as the per capita land availability is limited. The alternate means seems to be introducing short duration legumes in intercropping system. Of late, with the availability of short duration cultivars in redgram the uncertainity and erratic nature of weather make pigeonpea as sole crop for long duration troublesome, so the usage of short duration cultivars stabilizes the crop production under rainfed agriculture in coastal Andhra Pradesh. Growing alternate rows of pigeonpea may provide the resource based benefits of intercropping due to their variability in duration. In view of above points, this investigation was conducted.

MATERIAL AND METHODS

The field experiment was conducted on clay loam soils at the Agricultural College farm, Bapatla . The experimental soil had N, P_2O_5, K_2 O at 250, 13 and 500 kg ha^{-1}, respectively with a pH 7.8. The experiment was laid out in randomized block design with three replications. The treatments included sole crops of Abhaya (Long duration), Jagriti (Medium duration) and LBG -20 (blackgram) at spacings of 90 x 20 cm, 60 x 20cm and 30 x 10 cm, respectively, alternate rows of Abhaya + Blackgram and Jagriti + Blackgram intercropping maintained at the ratios of 1:2, 1:3 and 1:4. A common dose of 25 kg N, 50 kg P_2O_5 and 20 kg K_2O ha^{-1} was applied to intercrops. Land equivalent ratios, pigeonpea equivalent yields, monetary advantage and benefit cost ratio(BCR) were calculated.

RESULTS AND DISCUSSION

Plant height of Abhaya was significantly influenced at 90 DAS where the maximum (159.8 cm) was recorded with T_4 was nearly 11 to 12 per cent over T_7. Significantly highest number of primary branches per plant (15.4) was recorded in sole pigeonpea and it was on par with the cultivars of legumes sown alternatively at different population stand as confirmed by

Table 1 : Effect of intercropping on growth parameters, yield attributes and yield of medium duration Abhaya

Treatments		Plant height at 90 DAS (cm)	No.of primary branches at 90 DAS	No.of pods plant^{-1}	No.of seeds pod^{-1}	100 seed weight (g)	Seed yield kg ha^{-1}	Stalk yield kg ha^{-1}	Harvest index (%)
T_1	Sole Abhaya (ICPL-332)	154.8	15.4	99.6	3.6	7.6	985	3430	22.3
T_4	Alternate rows of Abhaya and Jagriti at 60 x 20 cm	159.8	15.1	79.4	3.6	7.4	545	2130	20.4
T_5	Alternate rows of Abhaya and Jagriti at 90 x 20 cm	148.8	13.8	93.3	3.6	7.2	448	1660	21.2
T_6	Alternate rows of Abhaya and Jagriti at 120 x 20 cm	153.6	14.2	107.0	3.7	7.6	365	1730	17.6
T_7	Abhaya + Blackgram 1:2	142.8	10.3	99.2	3.7	7.5	876	3260	21.2
T_8	Abhaya + Blackgram 1:3	145.2	11.3	114.2	3.8	7.6	750	2700	22.0
T_9	Abhaya + Blackgram 1:4	143.8	11.1	122.8	3.6	7.5	739	2460	23.2
	SEm±	3.6	1.0	3.0	0.1	0.1	23.6	156	1.5
	CD (P=0.05)	11.1	3.0	9.3	NS	NS	73.0	481	NS

Soundararajan and Palaniappan (1979). Highest number of pods per plant (122.8) was recorded when Abhaya was intercropped with blackgram in 1:4 proportion (T_9) and it was on par when the two legumes were intercropped in 1:3 proportion (T_8), (Table 1).

Number of pods per plant in T_9 increased by 54.6 and 31.6% over T_4 and T_5, respectively. The relatively less number of pods per plant recorded in keen competition for resources with varied plant densities. Number of seeds per pod and test weight differences among the treatments was not traceable (Table 1). Highest seed yield of 985 kg ha^{-1} was obtained in sole pigeonpea (T_1) and next best was T_7 *i.e.* Abhaya+ blackgram in 1:2 proportion. Seed yield of Abhaya improved by 16.8 and 18.5 % over T_8 and T_9, respectively when pigeonpea was intercropped with blackgram in 1:2 ratio of (T_7). Stalkyield also has shown the same trend as that of seed yield. Harvest index was not significantly influenced due to treatments (Table 1).

The data pertaining to pigeonpea equivalent yields, LER, monetary advantage and BCR are presented in Table 2 where maximum pigeonpea equivalents of 985 kg ha^{-1} was recorded with sole Abhaya (T_1) and the next best was Abhaya and blackgram intercropping in 1:2 proportion. The data indicated that intercropping of Abhaya with blackgram was better than a medium duration Jagriti+ blackgram in different proportion as reflected in pigeonpea equivalent yields and the same was in concurrence with Singh (1982). Maximum LER of 1:53 was recorded when Abhaya was intercropped with blackgram either in 1:2 or 1:4 ratios and closely followed by 1:3 Abhaya + blackgram treatment. The above mentioned treatment combinations were found to be significantly superior to rest of the treatments and they were equally effective among themselves.

Maximum monetary advantage of Rs. 3777 ha^{-1} was obtained when Abhaya and blackgram was intercropped in 1:2 proportion (T_7) and it was closely followed by the same crop combination 1:4 and 1:3 proportion. The lowest monetary advantage of Rs. 647 ha^{-1} was recorded with Jagriti+blackgram of 1:4 proportion. A negative monetary advantage was obtained when the two pigeonpea varieties were intercropped at different densities in conformation with Madhusudhana Rao *et al.*, (1989). Highest BCR

Table 2 : Effect of intercropping on pigenopea equivalent yield (kg ha^{-1}), LER, monetary advantage (Rs ha^{-1}) benfit-cost (B:C) ratio

	Treatments	Pigeonpea equivalent yield	LER	Monetary advantage	B:C ratio
T_1	Sole Abhaya (ICPL-332)	985	1.00	-	2.56
T_2	Sole Jagriti (ICPL-151)	373	1.00	-	0.53
T_3	Sole blackgram (LBG-20)	111	1.00	-	0.05
T_4	Alternate rows of Abhaya and Jagriti at 60 x 20 m	713	0.99	-82	0.80
T_5	Alternate rows of Abhaya and Jagriti at 90 x 20 cm	580	0.79	-1773	0.54
T_6	Alternate rows of Abhaya and Jagriti at 120 x 20 cm	471	0.64	-3046	0.36
T_7	Abhaya + blackgram 1:2	948	1.53	3777	1.94
T_8	Abhaya + blackgram 1:3	834	1.51	3240	1.77
T_9	Abhaya + blackgram 1:4	827	1.53	3292	1.88
T_{10}	Jagriti + blackgram 1:2	333	1.37	1035	0.16
T_{11}	Jagriti + blackgram 1:3	291	1.30	772	0.09
T_{12}	Jagriti + blackgram 1:4	265	1.26	647	0.05
	SEm±	-	0.02	-	-
	CD (P=0.05)	-	0.07	-	-

of 2.56 was noticed when Abhaya was grown as sole crop (T_1) which was followed by Abhaya and blackgram in 1:2 proportion with a BCR of 1.94. Intercropping Abhaya and blackgram in different proportions resulted in varied BCR from 1.94 to 1.77, which due to higher net returns obtained in the intercropping. The BCR obtained in Jagriti + blackgram in different proportions was negligible and so with monocrop of Jagriti or blackgram.

The study revealed that intercropping of Abhaya with blackgram was the most compatible and profitable system when compared with Jagriti+ blackgram combinations. The growing of alternate rows of the two pigeonpea varieties at any of spacings was not economical.

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Correlation and Path Coefficient Analyses in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

Correlation and path coefficient analysis using 52 sunflower inbreds during *rabi* 2002-2003 revealed that there was significant positive association and positive direct effect on seed yield per plant by plant height, stem diameter, head diameter, number of filled seed per head, total dry matter production per plant and harvest index. Hence, selection for these characters would be more effective to bring simultaneous improvement of yield and yield attributes in sunflower.

Key words: Correlation, Path Coefficient Analysis, Sunflower

Sunflower is a potential oilseed crop. Yield is a complex character and depends upon the expression and interaction of number of yield component characters. Correlation studies indicate the magnitude of association between any pair of characters which aids in selection of superior genotypes. Path analysis divides the correlation coefficients and enables the breeder to determine the magnitude of direct and indirect effects of different traits with seed yield.

MATERIAL AND METHODS

The present investigation was carried out during *rabi*, 2002-2003 at the Agricultural College Farm, Bapatla. The experiment was conducted in a randomized block design with three replications using 52 genotypes (inbreds) of sunflower. Each genotype was sown in three rows of 4.5 m length with inter-and intra-row spacing of 45 x 30 cm. Recommended agronomic practices were followed. Observations were recorded for yield and yield attributing characters such as days to 50% flowering, plant height, stem diameter, number of leaves per plant, days to maturity, head diameter, number of filled seed per head, 100-seed weight, total dry matter production per plant, seed yield per plant, oil content and harvest index.

The data collected on different characters were statistically analysed. Genotypic and phenotypic correlation coefficients were calculated as per Falconer (1964) and path coefficient analysis as suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among 52 genotypes for all the characters under study, thus indicating the existence of high variability for different characters.

Correlation studies (Table 1) indicated that genotypic and phenotypic correlations were on par. It also showed poor association of seed yield per plant with days to 50% flowering and days to maturity suggesting that duration of photosynthetic activity is not a limitation in sunflower. Significant positive association was observed for seed yield per plant with plant height, stem diameter, head diameter, number of filled seed per head, 100-seed weight, total dry matter production per plant, oil content and harvest index. These results were similar to

Table 1 : Phenotypic (P) and genotypic (G) correlation coefficients between seed yield and yield attributes in 52 genotypes of sunflower

Character		Plant height	Stem diameter	Leaves/ plant	Days to maturity	Head diameter	Filled seed/ head	100 seed weight	TDMP/ plant	Oil content	Harvest index	Seed yield/ plant
Days to 50% flowering	P	0.2641	-0.0683	0.0953	0.8614**	0.0057	-0.0755	-0.0844	0.0374	0.0041	-0.1419	-0.0831
	G	0.2835*	-0.0646	0.1005	0.9155**	0.0074	-0.0801	-0.0940	0.0367	0.0044	-0.1463	-0.0887
Plant height	P		0.3615**	0.5512**	0.3115*	0.3428*	0.2776*	0.3158*	0.6666**	0.1803	0.1245	0.3758**
	G		0.3782**	0.5700**	0.3220*	0.3686**	0.2880*	0.3299*	0.6836**	0.1908	0.1329	0.3833**
Stem diameter	P			0.0711	0.0476	0.4237**	0.8677**	0.6738**	0.8344**	0.5094**	0.9531**	0.8758**
	G			0.0720	0.0475	0.4416**	0.8931**	0.6941**	0.8658**	0.5374**	0.9772**	0.8832**
Leaves/plant	P				0.0849	0.1294	0.1172	-0.0251	0.3196**	0.0917	-0.0670	0.0998
	G				0.0920	0.1291	0.1190	-0.0275	0.3276**	0.1059	-0.0688	0.1019
Days to maturity	P					0.1086	-0.0192	0.0783	0.1477	0.0501	-0.0421	0.0445
	G					0.1173	-0.0203	0.0789	0.1472	0.0566	-0.0420	0.0513
Head diameter	P						0.3023*	0.4876**	0.4365**	0.2061	0.3870**	0.4435**
	G						0.3121*	0.5034**	0.4566**	0.2131	0.3978**	0.4616**
Filled seed / head	P							0.2686	0.7687**	0.5159**	0.8327**	0.8548**
	G							0.2716	0.7863**	0.5430**	0.8561**	0.8631**
100 seed weight	P								0.5664**	0.2843*	0.6494**	0.6870**
	G								0.5798**	0.2893*	0.6622**	0.6972**
TDMP/plant	P									0.4536**	0.6681**	0.8231**
	G									0.4760**	0.6861**	0.8498**
Oil content	P										0.4499**	0.4692**
	G										0.4753**	0.4834**
Harvest Index	P											0.8370**
	G											0.8543**

* Significant at 5% level ** Significant at 1% level TDMP = Total drymatter production

Table 2 : Path analysis for seed yield per plant (phenotypic), in 52 genotypes of sunflower

Character	Days to 50% flowering	Plant height	Stem diameter	Leaves/ plant	Days to maturity	Head diameter	Filled seed/ plant	100 seed weight	TDMP/ plant	Oil content	Harvest index
Days to 50% flowering	**-0.0692**	-0.0183	0.0047	-0.0066	-0.0596	-0.0004	0.0052	0.0058	-0.0026	-0.003	0.0098
Plant height	0.0308	**0.1167**	0.0422	0.0643	0.0364	0.0400	0.0324	0.0369	0.0778	0.0210	0.0145
Stem diameter	-0.0304	0.0408	**0.1404**	0.0317	0.0212	0.0888	0.0865	0.0901	0.0717	0.0269	0.0264
Leaves/plant	0.0029	0.0167	0..0021	**0.0302**	0.0026	0.0039	0.0035	-0.0008	0.0097	0.0028	-0.0020
Days to maturity	0.0521	0.0189	0.0029	0.0051	**0.0605**	0.0066	-0.0012	0.0047	0.0089	0.0030	-0.0025
Head diameter	0.0000	0.0002	0.0002	0.0001	0.0001	**0.0005**	0.0001	0.0002	0.0002	0.0001	0.0002
Filled seed / head	0.0022	0.1120	0.4429	-0.0034	0.0006	0.1529	**0.6012**	0.3023	0.3779	0.2851	0.4542
100 seed weight	0.0010	-0.0039	-0.0084	0.0003	-0.0010	-0.0061	-0.0033	**-0.0124**	-0.0070	-0.0035	-0.0081
TDMP/plant	0.0018	0.0316	0.0396	0.0152	0.0070	0.0207	0.0365	0.0269	**0.0475**	0.0215	0.0317
Oil content	-0.0001	-0.0041	-0.0116	-0.0021	-0.0011	-0.0047	-0.0118	-0.0065	-0.0104	**-0.0229**	-0.0103
Harvest Index	-0.0743	0.0651	0.2206	-0.0350	-0.0220	0.1413	0.1056	0.2397	0.2495	0.1353	**0.3231**
Correlation coefficient with seed yield/plant	-0.0831	0.3758**	0.8758**	0.0998	0.0445	0.4435**	0.8458**	0.6870**	0.8231**	0.4692**	0.8370**
Partial R^2	0.0057	0.0439	0.1230	0.0030	0.0027	0.0002	0.5139	-0.0085	0.0391	-0.0107	0.2704

** Significant 1% level   Residual effect = 0.1315   Numbers in bold indicate direct effects of characters on yield

TDMP = Total drymatter production

those obtained by Patil *et al.*, (1996) and Teklewold *et al.*, (2000). It also indicated that seed yield, 100-seed weight and oil content are inherited together and selection for one character may cause corresponding improvement in other character, finally resulting in increased seed yield with good oil percentage. Hence, selection for these traits may result in superior genotypes in sunflower.

The path analysis (Table 2) revealed that plant height, stem diameter, head diameter, number of filled seed per head, total dry matter production per plant, harvest index, days to maturity and number of leaves per plant had positive direct effect on seed yield per plant.

Barring the last two characters all the other traits had significant positive correlation with seed yield per plant. In spite of high and positive correlation of 100-seed weight and oil content with seed yield per plant, the direct and indirect effects of other traits through them were negative. Nevertheless, the high positive correlation observed between these traits and seed yield per plant is partially explainable by their high positive indirect effect through number of filled seed per head and harvest index. Similar reports were obtained by Narasaiah (1995) and Ashok *et al.* (2000).

The results emanated from path coefficient analysis indicated that the direct effect was maximum for number of filled seed per head followed by harvest index, in accordance with Ravi (2001). Hence selection for the characters having both positive direct effect and positive significant correlation with seed yield per plant giving more emphasis on number of filled seed per head and harvest index would be more effective to bring simultaneous improvement of yield and yield attributes in sunflower.

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Genetic Divergence in Greengram [*Vigna radiata* (L.) Wilczek]

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ABSTRACT

Sixty greengram [*Vigna radiata* (L.) Wilczek] genotypes were grouped into eight clusters based on genetic diversity. Highest inter-cluster value was observed between clusters V and VII, I and VII, V and VIII, II and VIII, VII and VIII. Clustering patterns of genotypes did not follow geographical origin, suggesting that geographical isolation may not be the only factor causing genetic diversity. Out of thirteen characters studied days to maturity, 100- seed weight, pods per plant, plant height and total dry matter contributed maximum to genetic diversity in greengram.

Key words : Greengram, Genetic Divergence

Greengram [*Vigna radiata* (L.) Wilczek] is one of the important pulse crops. Lack of genetic diversity is one of the basic causes for relatively poor success in raising the yield level in greengram (Ramanujam, 1978). Hence, the present study was undertaken to ascertain the nature and magnitude of genetic diversity to identify suitable donors having wider genetic distance in greengram.

MATERIAL AND METHODS

The experiment was conducted during *rabi* 2002 in randomised block design with two replications at Regional Agricultural Research Station, Lam. The experimental plot consisted of two rows with a inter-row spacing of 30 cm and intra-row spacing of 10 cm. A basal dose of fertilizer was applied at the rate of 20 kg N, 50 kg P_2O_5 per hectare. Five plants from each genotype and in each replication were selected at random from the middle of the rows excluding the border plants.

Observations were recorded on 13 characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of clusters per plant, number of pods per plant, pod length (cm), number of seeds per pod, 100-seed weight, seed yield per plant (g), total drymatter per plant (g), protein content (%) and harvest index (%). Multivariate analysis was done following Mahalanobis (1936) and genotypes were grouped into different clusters following Tocher's method as described by Rao (1952).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for the thirteen characters except harvest index and protein content. It indicated the existence of genetic variability among the genotypes. The multivariate analysis giving the D^2 values between 60 genotypes revealed that these genotypes can be grouped into eight clusters (Table 1).

Table 1 : Distribution of 60 genotypes of greengram in different clusters

Cluster	No.of genotypes	Genotypes
I	15	AKM 9242, Sipai, HUM 1, ML 803, PDM 84-139, K 851, M 1319B, LGG 460, Ganga 8, PS 16, Pusa Baisaki, LGG 446, Pusa 102, ML955
II	3	BDYR 3, TM 99-15, UPM 79-3-4
III	8	AKM 9243, Pusa 105, Pusa bold, M 1643, Pusa 9072, TM 96-2, M 1218, Pusa Visal
IV	14	LGG 407, LGG 450, LGG 444, WGG 37, VGG 14, LGG 521, MGG 347, Neelalu, M 1475, ML 613, TARM-1, ML-267, ML33, PDM 54
V	9	Basanti, BDYR 1, BDYR 4, NM 1, VC 6173A, NM 92, VC 3960-88, UPM 98-1, VC 6370
VI	7	WGG 2, LGG 410, CO 4, LGG 456, M 59, LGG 494, LGG 489
VII	1	Lam M2
VIII	3	M 501, M 638, M 1450

The results obtained from the analysis for estimating the contribution of various characters towards genetic divergence are given in Table 2. Days to maturity contributed maximum towards the total divergence (22.11%) followed by 100-seed weight (19.60%), pods per plant (14.69), plant height (11.47%), total drymatter (11.19%). Rawale *et al.,* (1996) analysed 12 yield related characters by using Mahalanobis' D^2 statistics in 70 genotypes of cowpea. Multivariate analysis grouped the genotypes into 19 clusters. Days to 50% flowering and maturity, number of pods per plant, pod length, 100-seed weight, seed yield per plant and harvest index made the largest contribution to the total divergence.

The maximum intra-cluster distance (212.57) was noticed in cluster VIII followed by Cluster IV (184.19). The lowest intra-cluster distance was noticed in cluster II (36.31) followed by cluster I (66.08). The maximum inter-cluster distance was recorded between cluster V and cluster VII (1588.34) followed by I and VII (1122.92) and cluster V and VIII (1066.20) while the lowest D^2 value was recorded between cluster I and II (135.93) followed by cluster I and V (176.46) and cluster I and IV (193.04) (Table 3).

The relative importance of the yield components contribution towards divergence can be judged by comparing the group means of the thirteen characters (Table 4). Genotypes with high protein content, low pod length and low grain yield were included in cluster I. Cluster II had the genotypes with high number of clusters per plant and more number of seeds per pod. Cluster III possessed genotypes having high harvest index with low plant height. Genotypes with moderate 100-seed weight and low number of seeds per pod were included in cluster IV. The genotypes in cluster V were early flowering, early maturing, bold seeded, with less number of branches per plant, clusters per plant, pods per plant, seeds per pod and total dry matter.

Genotypes with moderate plant height and clusters per plant were included in this cluster VI. Cluster VII contains single genotype, which was late in maturity with tall plant habit and low harvest index. Cluster VIII had genotypes with more pod length, yield per plant and total dry

Table 2 : Contribution of different characters towards genetic divergence in greengram

Character	Per cent Contribution towards divergence (%)	Rank
Days to 50% flowering	5.31	8
Days to maturity	22.11	1
Plant height	11.47	4
Branches per plant	5.71	7
Clusters per plant	0.04	13
Pods per plant	14.69	3
Pod length	2.43	9
Seeds per pod	7.12	6
100-seed weight	19.60	2
Yield per plant	0.17	10
Total drymatter	11.19	5
Harvest index	0.11	11
Protein content	0.06	12

Table 3 : Intra- and inter-cluster (D^2) values of eight clusters in greengram

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8
Cluster 1	**66.08**	135.93	223.59	193.04	176.46	373.03	1122.92	823.11
	(8.12)	(11.65)	(14.90)	(13.89)	(13.28)	(19.31)	(33.50)	(28.69)
Cluster 2		**36.31**	301.96	232.83	282.03	320.33	907.15	980.94
		(6.02)	(17.3)	(15.25)	(16.79)	(17.89)	(30.11)	(31.32)
Cluster 3			**172.52**	274.29	388.72	288.93	957.46	446.05
			(13.13)	(16.56)	(19.716)	(16.99)	(30.94)	(21.12)
Cluster 4				**184.19**	435.76	283.45	816.07	723.07
				(13.57)	(20.87)	(16.83)	(28.56)	(26.89)
Cluster 5					**103.53**	678.28	1588.34	1066.02
					(10.17)	(26.04)	(39.85)	(32.65)
Cluster 6						**174.39**	417.30	492.84
						(13.20)	(20.42)	(22.20)
Cluster 7							**0.00**	920.51
							(0.00)	(30.34)
Cluster 8								**212.57**
								(14.58)

Square root values of D^2 are given in parentheses
Bold figures indicate intra-cluster values

Table 4 : Mean values of characters in different clusters in greengram

	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant	Clusters per plant	Pods per plant	Pod length (cm)	Number of seeds per pod	100 seed weight (g)	Yield per plant (g)	Total dry matter (g)	Harvest index (%)	Protein content (%)
Cluster 1	32.03	63.30	38.96	1.70	6.47	22.46	6.58	10.43	4.05	9.51	28.06	33.90	22.91
Cluster 2	33.83	68.66	43.26	2.53	9.63	24.23	7.38	11.80	4.60	13.26	37.41	35.18	22.61
Cluster 3	33.75	65.06	35.52	3.18	8.76	38.32	7.24	10.39	4.20	16.51	44.85	36.71	22.92
Cluster 4	33.75	66.78	42.82	2.63	8.14	27.43	6.74	9.67	3.54	9.59	28.93	33.20	22.78
Cluster 5	28.72	59.55	42.36	1.35	5.62	19.97	7.45	9.75	4.87	9.65	27.73	34.29	22.69
Cluster 6	37.42	72.28	44.72	2.60	8.77	35.36	7.35	10.96	3.96	15.43	46.67	33.10	22.94
Cluster 7	42.50	83.50	62.15	2.60	6.00	31.01	7.50	10.60	4.01	13.20	41.70	32.03	22.32
Cluster 8	34.33	67.00	38.73	3.40	8.98	56.26	8.00	10.56	3.89	23.01	69.56	33.14	22.48

matter. The crosses can be effective between the genotypes of cluster V and VII, cluster I and VII and V and VIII where the maximum inter-cluster distance was exhibited for getting desirable genotypes. The clustering pattern obtained in the present investigation showed that there was no relationship between geographic distribution and genotypic diversity as genotypes from different geographic origin were grouped in one cluster.

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Breeding for Better Reproductive Efficiency, Source-Sink Relationship and Sexual Strategy in Sesame (*Sesamum Indicum* L.)

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ABSTRACT

Twenty one genotypes of sesame (*Sesamum indicum* L.) differed among themselves for 15 out of 16 characters studied. It was found out that "*source is well limited*" in sesame. There was a wider gap between observed number of seeds per plant and expected number of seeds per plant. It may be hypothesized that " *the level of material investment on the number of potential capsules and ovules is determined by a series of space and time specific controls".* Higher genotypic variability coupled with higher heritability and genetic advance were recorded for 11 out of 16 characters studied. Studies on correlation and causation revealed that number of capsules per plant and number of filled seeds per plant as the characters of choice for seed yield improvement in sesame.

Key words : Sesame, Breeding Strategy

Sesame is one of the important oils seed crops in many parts of the world. Despite the concerted efforts, the seed yield remained to be low. Large scale shedding of the reproductive organs is one of the major constraints in achieving higher seed yield in sesame (Saha and Bhargava, 1982). The present study analyses the reproductive efficiency, source sink relationship and sexual strategy manifested by this ancient oilseed crop.

MATERIAL AND METHODS

Self fertilized, well filled, sound and plumply seeds for twenty one genotypes of sesame *viz.*, G1) Si.154, G2) IS.366, G3) Nathonsun, G4) Co.1, G5) Gun. 14, G6) Si.1615, G7) Si.280, G8) Si.1684, G9) Si.1711, G10) Si.3256, G11) Si.1260, G12) TMV.6, G13) Vs.9701, G14) Si.3260, G15) Si.3232, G16)AVTS.99-6, G17) AVTS.99-4, G18) SVPR.1, G19) IVTS.99-11, G20) IVTS.99-112, G21) IVTS.99-13 were sown and studied during Feb-May, 2000. The seeds were sown in randomized block design, with three replications. The inter-row spacing was 30 cm and intra-row spacing was 15 cm. Recommended agronomic practices and need based plant protection measures were taken. Randomly selected, five healthy and competing plants were tagged before the on set of the reproductive phase. Observations were recorded on the formation and shedding of reproductive organs, from the day of first bud appearance, until maturity.

Observations were recorded on the following 16 traits *viz.*, X1) number of buds per plant, X2) number of flowers per plant, X3) number of capsules per plant X4) reproductive efficiency I, X5) reproductive efficiency II, X6) reproductive efficiency III, X7) number of leaves at the time of the first bud formation, X8) number of leaves at the time of first flower formation,

Table 1 : Mean performance of sesame genotypes

Genotypes	Characters															
	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X 10	X 11	X 12	X 13	X 14	X 15	X 16
G1	84.07	80.33	72.27	95.57	90.77	94.97	43.47	46.00	26.80	286.46	45.87	3466.00	2651.00	2185.40	465.60	6.77
G2	55.53	50.73	47.60	91.33	85.66	93.85	39.33	45.93	22.47	212.03	48.20	2269.06	1971.73	1647.40	324.33	5.83
G3	38.87	34.60	31.93	89.09	82.21	92.27	32.07	48.93	32.20	99.19	47.53	1507.40	1352.33	115.86	236.47	5.33
G4	56.47	52.87	48.73	94.22	86.25	92.11	38.20	40.40	18.20	267.93	47.80	2345.87	2059.67	1611.06	448.60	8.20
G5	72.93	68.13	63.73	93.48	87.46	99.56	31.27	30.87	26.60	239.99	41.47	2691.13	2256.13	1751.00	505.13	5.53
G6	71.07	67.67	64.07	95.25	90.20	94.69	32.47	36.40	18.80	340.40	43.73	2835.53	2380.67	1789.13	519.53	6.33
G7	75.67	68.60	64.53	90.82	85.44	94.06	20.60	34.00	21.47	301.57	45.33	2951.20	2422.40	2016.13	406.27	6.23
G8	57.87	54.33	50.53	93.89	87.34	94.06	29.00	35.53	32.47	156.05	45.00	2444.60	2390.93	1952.53	438.40	5.83
G9	80.33	77.40	72.27	96.38	90.18	93.54	36.60	41.30	26.60	272.18	47.47	3505.00	2993.20	2651.20	342.00	7.17
G10	67.27	64.07	60.67	95.44	90.21	94.69	33.47	34.87	21.20	287.40	50.47	3050.80	2555.93	2117.93	438.00	6.37
G11	66.40	63.13	58.73	95.18	86.68	93.15	36.13	39.20	28.07	210.24	49.60	2942.87	2659.60	2142.07	517.53	6.60
G12	64.93	61.93	57.27	95.43	88.17	92.45	29.33	37.33	21.80	267.66	47.80	2720.40	2229.06	1692.20	536.87	7.20
G13	75.40	72.40	67.87	95.98	89.96	93.73	32.33	34.73	25.93	262.67	48.27	3261.26	2906.46	2470.46	432.00	8.07
G14	34.06	30.93	27.47	90.83	80.64	88.73	21.47	26.07	15.87	174.04	46.93	1307.27	1289.80	1085.73	204.07	4.20
G15	47.53	43.47	40.27	91.32	84.57	92.59	17.07	23.73	18.53	216.72	53.33	2143.07	1764.20	1424.67	339.53	4.70
G16	69.00	63.93	60.47	92.63	87.64	94.63	14.07	25.80	19.27	313.89	53.60	3244.98	2700.20	2249.87	450.33	7.20
G17	54.87	50.93	48.13	93.24	88.00	94.41	21.27	24.87	17.80	270.37	55.00	2489.73	2167.53	1834.13	333.40	6.03
G18	92.40	89.13	83.47	96.49	90.34	93.64	36.03	42.73	27.07	309.67	51.87	4319.33	3654.60	3191.07	463.53	9.17
G19	54.20	50.73	46.40	93.61	85.53	91.36	14.60	33.27	15.53	298.92	53.40	2462.13	2060.27	1652.87	407.40	6.00
G20	65.73	61.73	57.73	93.94	87.85	93.49	20.73	28.67	18.33	315.82	48.60	2822.80	2317.80	1970.13	347.67	6.50
G21	65.33	62.27	58.07	95.28	88.88	93.27	34.33	36.53	25.93	225.69	49.20	2844.46	2307.86	1774.60	533.27	6.67
Grand mean	64.28	60.44	56.29	93.78	87.43	93.53	29.23	35.58	22.90	253.76	48.59	2744.04	2337.49	1920.26	417.23	6.47
'F' value	34.56**	42.94**	38.06**	2.61**	3.11**	1.73	38.26**	22.66**	20.60**	21.56**	2.12**	12.13**	9.46**	8.09**	58.44**	10.95**

** Significant at 1% level ; * Significant at 5% level

Table 2 : Heritability (broad sense), genetic advance and genetic advance as % of mean in sesame genotypes

Characters	σ^2g	σ^2p	$h_2\%$	GA	GA% over mean
X1	197.20	214.83	91.79	27.71	43.11
X2	198.63	212.84	93.32	28.04	46.40
X3	183.52	198.38	92.51	26.84	47.51
X4	2.69	7.73	34.85	1.99	2.129
X5	5.00	12.12	41.25	2.95	3.384
X6	0.83	4.24	19.55	0.83	0.89
X7	71.68	77.45	92.54	16.77	57.40
X8	49.61	56.48	87.83	13.59	38.22
X9	24.31	28.03	86.72	9.46	41.30
X10	3408.89	3906.28	87.26	112.35	44.27
X11	6.30	23.10	27.27	2.70	5.55
X12	407293	517045.40	78.77	116.83	42.52
X13	250880	339796.80	73.83	886.59	37.92
X14	205490	292375.20	70.28	782.86	40.76
X15	9540.52	10038.8	95.03	196.15	47.01
X16	1.19	1.55	76.83	1.97	30.47

σ^2g = Genetic variance, σ^2p = Phenotypic variance, h_2 = Heritability, GA = Genetic advance

X9) number of leaves at the time of harvest, X10) source-sink ratio, X11) number of seeds per capsule, X12) number of seeds per plant, X13) observed number of seeds per plant, X14) number of filled seeds per plant, X15) number of ill filled seeds per plant and X16) seed yield per plant. Out of the 16 traits studied, only nine characters *viz.*, X1, X2, X3, X7, X8, X9, X11, X14 and X16 were considered for the studies on correlation and causation function for the ease of computer analyses. Reproductive efficiencies were calculated as follows:

$$\text{Reproductive efficiency I} = \frac{\text{Total number of flowers per plant}}{\text{Total number of buds per plant}} \times 100$$

$$\text{Reproductive efficiency II} = \frac{\text{Total number of capsules per plant}}{\text{Total number of buds per plant}} \times 100$$

$$\text{Reproductive efficiency III} = \frac{\text{Total number of capsules}}{\text{Total number of flowers per plant}} \times 100$$

Standard statistical procedures were adopted.

RESULTS AND DISCUSSION

The analyses of variance for the 16 characters revealed that there exists highly significant differences among the 21 genotypes for 15 characters. This indicated that the genotypes under the study are genetically highly different (Table 1).

The mean performance of the 21 genotypes for 16 traits are presented in Table 1. There were profligate loss of flower buds, open flowers and there after immature capsules. Seven factors have been suggested for the loss

Table 3 : Correlation coefficients among reproductive characters in sesame

Characters		X1	X2	X3	X7	X8	X9	X11	X14
	P	0.6809**	0.6839**	0.6806**	0.3663	0.3238	0.1735	0.2222	0.7651**
X16	G	0.7441**	0.7659**	0.7550**	0.4159*	0.3799	0.1717	0.0471	0.7772**
	E	0.4059	0.2849	0.3349	0.1184	0.0693	0.1903	0.4887	0.7393**
	P		0.2849	0.9921**	0.3745	0.2419	0.2858	-0.0908	0.8258**
X1	G		0.9936**	1.0012**	0.3946	0.2665	0.2845	-0.2496	0.9235**
	E		0.9999**	0.8866**	0.1381	0.0264	0.3056	0.1394	0.5387**
	P		0.9209**	0.9972	0.3970	0.2559	0.2852	-0.1028	0.8212**
X2	G			1.0005**	0.4174**	0.2721	0.2937	-0.2186	0.9393**
	E			0.9557**	0.1289	0.1058	0.2233	0.0339	0.4294*
	P				0.3976	0.2534	0.2849	-0.0994	0.8248**
X3	G				0.4169*	0.2698	0.2920	-0.2174	0.9324**
	E				0.1580	0.1071	0.2336	0.0417	0.4896*
	P					0.7717**	0.5424**	-0.2900	0.2687
X7	G					0.8288**	0.5930**	-0.6540**	0.2904
	E					0.2566	0.1119	0.1657	0.2318
	P						0.5615**	-0.2475	0.1740
X8	G						0.6392**	-0.4517*	0.1918
	E						0.0279	-0.0887	0.1225
	P							-0.2088	0.2978
X9	G							-0.6041**	0.2978
	E							0.2735	0.2962
	P								0.3348
X11	G								0.27983
	E								-0.0141
	P								0.6119**

P, G, E = Phenotypic, Genotypic, and Environmental correlations.
**Significant at 1% level * Significant at 5% level

of reproductive potential in cowpea (Ojehomon, 1968; Sinha, 1977; Summerfield and Wein, 1980). In the present study, maximum shedding occurred in buds followed by capsules and flowers. This suggested that the loss of reproductive organs take place before and after pollination and fertilization in sesame. As a token of sexual strategy, the mother plant sesame may have decided its family size. There may also be a serial adjustment of maternal investment. The mother plant sesame may have withdrawn its the development of earlier formed capsules and there by strengthened the older capsules. The shedding may also be due to competition of assimilates between strong sinks (*i.e.*, developing capsule) and weaker sinks (*i.e.* flower buds as well as opened flowers), actuated through various mechanisms.

The comparatively less shedding of flowers may be attributed to the synthesis of auxin in the flower parts which eventually increased after pollination (Takeyashi and Fuji,

Table 4 : Direct and indirect effects of reproductive characters towards yield in sesame

Characters	X1	X2	X3	X7	X8	X9	X11	X14	X16
X1	**0.5087**	-4.6710	3.8779	0.0986	0.0868	-0.0919	-0.0313	0.9662	0.74411**
X2	0.5087	**-4.6715**	3.8752	0.1044	0.0887	-0.0948	-0.0274	0.9828	0.7659**
X3	0.5093	-4.6737	**3.8734**	0.1043	0.0878	-0.0944	-0.0273	0.9755	0.7550**
X7	0.2007	1.9500	1.6148	**0.2501**	0.2701	-0.1916	-0.0819	0.3038	0.4159*
X8	0.1355	-1.2711	1.0448	0.2073	**0.3258**	-0.2066	-0.0566	0.2007	0.3799
X9	0.1447	-1.37719	1.1312	0.1483	0.2083	**-0.3230**	-0.0757	0.3099	0.1717
X11	-0.1269	1.0213	-0.8422	-0.1636	-0.1472	0.1952	**0.1253**	-0.01472	0.0471
X14	0.4698	-4.3879	3.6114	0.0726	0.0625	-0.0957	-0.0017	**1.0463**	0.7772**

1960). The cessation of such hormones at capsule development stage may be the cause for the excess of capsule shedding. This may be coupled with small leaf area available in terms of number and size of individual leaf at the time of capsule development. Sesame is heterophyllous in nature. The higher the position of leaves on sesame plant the smaller will be its leaf area, which may restrict the supply of assimilates to the developing capsules and make then more liable to shedding. So, there exists a spatial and temporal adjustment of maternal investment in sesame. Hence, in seeking for yield improvement in sesame, primary consideration must be given to increase the number of capsules per plant.

There was a small increase in the number of leaves per plant at the time of flower formation, when compared with that of bud formation. On the contrary, there was a reduction in the number of the leaves at the time of harvest, when compared with that of flower formation. That is, during the capsule development stage, there existed a starvation for assimilates, due to ageing and senescence of the major photosynthesizing surface *i.e.*, leaves. It amply indicated that "*source is well limited in sesame*". The source sink ratio (the ratio of number of leaves at the time of flowering to the number of leaves at the time of the harvest was less than 1:1. It is suggested to broaden the ratio to atleast 1:1. Further, there was a wider gap between the observed number of seeds per plant and expected number of seeds per plant. About 18 per cent of the seeds were ill filled. This may also be due to the non-availability of assimilates. In seeking yield improvement in sesame, due weightage must be given for delayed ageing and senescence of the leaves. In view of the above results, it may be hypothesized that" the level of material investment on the number of potential capsules and ovules is determined by a series of space and time specific controls". According to Llyod (1980), this serial adjustment hypothesis is explained in three parts *viz.*, 1) the amount of maternal investment is regulated at many developmental units at three principal stages, namely a) the determination of flower buds, b) the development of flower and c) the maturation of the capsules, 2) at each developmental sites, the maternal investment is continuously adjusted to the assimilates available. If the assimilate is adequate then the supply is continued, otherwise not, 3) the pattern of control that maximize the maternal fitness of the plant is selected.

The high seed yielding genotype namely, SVPR. 1 (9.17 g seeds per plant), possessed a reproductive efficiency 1 of 96.49 per cent, reproductive efficiency II of 90.34 per cent and reproductive efficiency III of 93.64 per cent and a source sink ratio of 1:0.32 and ratio of ill filled seeds 12.68 per cent. This genotype may be considered as " model genotype" and be utilised in cross breeding program.

Higher genotypic variance coupled with higher genetic advance as percentage over mean were observed for number of buds, flowers, and capsules; number of leaves at the time of first bud formation and at the time of harvest; source sink ratio, expected and observed number of seeds per plant; and number of filled and ill filled seeds per plant (Table 2). This indicated that the aforementioned characters were controlled by additive genes. So, these characters could well be improved by restoring to simple pure line selection. Other characters exhibited moderate heritability coupled with low genetic advance. These traits may be controlled by non-additive genes and hence could well be improved by delaying the selection to later generations, after generating variations.

The studies on correlation and causation revealed the superiority of the characters *viz.*, number of capsules per plant and number of filled seeds per plant. These traits portrayed positive significant phenotypic, genotypic and environmental association with seed yield per plant. The *inter se* correlation among these characters were also positive (Table 3). They exerted maximum positive direct effects towards seed yield per plant. Moreover, through these characters only all the other traits exerted their maximum positive indirect effects (Table 4). Hence, number of capsules and filled seeds per plant and seed yield *per se* may well be declared as the *choice of characters* for the yield improvement in sesame.

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Genetic Divergence Among Mutant Cultures Developed from Greengram Variety Pusa Vishal

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ABSTRACT

Forty-eight mutant cultures developed from greengram variety Pusa Vishal through mutagenic treatment with four doses each of Gamma-rays, EMS and NG were evaluated along with parent for nine quantitative traits. Genetic divergence among the 49 entries ranged from 1.60 to 95.6 indicating that mutagenic treatments were effective in inducing enough genetic variability in the traits and thereby resulting in development of genetically diverse mutant genotypes. The characters, 100-seed weight, days to maturity and pods /plant showed high contribution to induced genetic divergence. Using Tocher' s method the 48 mutant cultures were grouped into nine genetic clusters. Fourteen of these cultures were grouped with the parent variety in Cluster 1, while rest 34 cultures grouped into 8 divergent clusters. Clustering pattern revealed that the cultures developed from same mutagenic treatment often grouped into different clusters. The 16 cultures developed from each of Gamma-rays, EMS and NG treatments grouped into 4, 6 and 6 different clusters. Thus, mutagenic treatments were effective in inducing diversified changes in the quantitative traits. Taking D^2 and mean values of component traits and yield into consideration the crosses PVE 2-1 x PVN 1-2, PVE 2-1 x PVN 4-2 and PVN 1-2 x PVN 4-2 are expected to produce more high yielding segregants.

Key words : Greengram, Mutant, Genetic Divergence

Induction of mutations through physical or chemical mutagens provide a powerful means of creating new and useful variability in crop plants both in qualitative and quantitative characters leading to isolation of superior mutants. Thus, it would be of interest to ascertain how the different mutant cultures developed from the same parent differ from the parent and also among themselves. Univariate analysis may not be adequate to distinguish among the micro-mutants with small differences in many of the quantitative traits. Multivariate analysis, which takes into consideration several quantitative characters simultaneously, would be a dependable method in determining stable differences among the micro- mutants use of multivariate analysis for identification and classification of micromutants have been reported by Mohapatra *et al.*, (1983 and 1987 Sarma and Talukdar (1991) in greengram and Mishra (1995) in blackgram. The present study, pertaining to mutant cultures of greengram, multivariate analysis of genetic divergence is used for identification of micro-mutants.

MATERIAL AND METHODS

The greengram variety Pusa Vishal was given mutagenic treatments with gamma-rays, ethyl methane sulphonate (EMS) and nitroso guanidine (NG). The twelve mutagenic treatments were 15, 30, 45, 60 kR of gamma - rays (G1, G2, G3, G4), 0.15, 0.30, 0.45, 0.60% of EMS (E1, E2, E3, E4) and 0.005, 0.010, 0.015, 0.020 % of NG (N1, N2, N3, N4). Dry seeds were given gamma-rays treatments while 6 hours pre-soaked seeds were given EMS and NG

Table 1 : Relative contribution of different characters to the genetic divergence in the mutant cultures of greengram variety Pusa Vishal

Character	Rank (Total)	Rank (Average)	Average D^2	% of total D^2
1. Days to flowering	5681	4.83 (5)	3.35	11.55 (5)
2. Days to maturity	5087	4.32 (2)	4.22	14.55 (3)
3. Plant height	5610	4.77 (4)	3.39	11.69 (4)
4. Branches / plant	7185	6.11 (9)	1.33	4.59 (9)
5. Clusters / plant	6838	5.81 (7)	1.50	5.17 (8)
6. Pods / plant	5234	4.45 (3)	4.27	14.72 (2)
7. Seeds / pod	5982	5.09 (6)	2.54	8.76 (6)
8. 100-seed weight	4462	3.79 (1)	6.59	22.72 (1)
9. Yield / plant	6848	5.82 (8)	1.81	6.24 (7)

Note : Number in parenthesis indicate order of contrbution (descending) to genetic divergence.

treatments for 6 hours. M_1 generation was grown and harvested as treatment bulk. In M_2 generation, all chlorophyll and morphological macro-mutants were identified and harvested separately. For study of induction of micro-mutations observations on 60 normal looking plants from each treatments was taken and 12 higher yielding M_2 plants were taken for M_3 study. In M_3 generation, the 12 plant progenies from each of the twelve mutagenic treatments along with parent variety were grown in compact family block design. On the basis of higher yield 4 progenies from each of 12 treatments were selected and in M_4 generation the 48 mutant cultures along with parent were sown on 7th July, 2003 in randomized block design with three replications. Observations on days to flowering and maturity were taken on plot basis and observations on component traits and yield were recorded by taking 10 random plants per culture in each replication. Mahalanobis' D^2 statistic (Rao, 1952) was used for estimation of genetic divergence among the mutant cultures with respect to nine quantitative characters and grouping of mutants into different clusters was done by Tocher's method (Rao, 1952).

RESULTS AND DISCUSSION

The genetic divergence (D^2) among the 49 entries comprising 48 mutant cultures and parent variety Pusa Vishal were estimated. The D^2 values for all the 1176 paired combinations among the 49 entries varied from 1.60 to 95.6 indicating that mutagenic treatments were effective in inducing enough genetic variability in different quantitative traits. Thereby resulting in development of mutant genotypes with genetic diversity among themselves. Moreover the mutant cultures PVE 3-4, PVE 2-1, PVE 2-4, PVN 1-2, PVE 2-2, PVE 2-3 and PVN 4-2 showed high genetic divergence (D^2) from the parent variety.

The relative contribution of the nine quantitative characters to genetic divergence among the mutant cultures were estimated by two parameters *i.e.* rank average and average D^2 (Table 1). Contribution towards genetic divergence was maximum by 100-seed weight closely followed by pods/plant and days to maturity and their combined contribution to divergence was 52%. Thus, it appears that mutagenic treatments were effective in inducing

Table 2 : Grouping of mutant cultures of greengram variety Pusa Vishal into different genetic clusters.

Cluster No.	Number of	Name of the culture (with entry number)
I	15	PVG 1-1 (1), PVG 1-4 (4), PVG 3-2 (10), PVG 3-3 (11), PVG 4-1 (13), PVG 4-2 (14), PVE 4-2 (30), PVE 4-3 (31), PVE 4-4 (32), PVN 1-3 (35), PVN 2-2 (39), PVN 3-3 (43), PVN 3-4 (44), PVN 4-3 (47), Pusa Vishal (Parent) (49)
II	17	PVG 1-2 (2), PVG 1-3 (3), PVG 2-2 (6), PVG 2-3 (7), PVG 3-1 (9), PVG 4-3 (15), PVG 4-4 (16), PVE 1-1 (17), PVE 1-3 (19), PVE 1-4 (20), PVN 1-1 (33), PVN 1-4 (36), PVN 2-1 (37), PVN 2-4 (40), PVN 3-1 (41), PVN 3-2 (42), PVN 4-4 (48)
III	10	PVG 2-1 (5), PVG 3-4 (12), PVE 2-2 (22), PVE 2-3 (23), PVE 2-4 (24), PVE 3-1 (25), PVE 3-2 (26), PVE 3-3 (27), PVE 4-1 (29), PVN 2-2 (38)
IV	2	PVG 2-4 (8), PVN 4-1 (45)
V	1	PVN 1-2 (34)
VI	1	PVE 2-1 (21)
VII	1	PVE 3-4 (28)
VIII	1	PVE 1-2 (18)
IX	1	PVN 4-2 (46)

more of heritable variation in these three traits. High contribution of these traits to genetic divergence is in broad agreement with reports on contribution of traits to genetic divergence among mutant cultures by Mohapatra *et al.* (1987), Sarma and Talukdar (1991) and Mishra (1995). Moreover, contribution of branches per plant, clusters per plant and yield per plant to genetic divergence was very low.

Following Tocher' s method of grouping using D^2 values, the 48 mutant cultures and the parent variety grouped into nine different clusters (Table 2). Of these 48 cultures, 14 cultures (6 from Gamma-rays, 3 from EMS and 5 from NG treatments) grouped along with parent variety in cluster 1. Thus, these cultures do not possess enough genetic differences from the parent in the different traits. The remaining 34 cultures grouped into eight other divergent genetic clusters. The cultures II was the largest group comprising 17 cultures while clusters III and IV had 10 and 2 cultures, respectively. The remaining 5 clusters were represented by one culture each. A close examination of clustering pattern of the mutant cultures revealed that clusters (representing more than one culture) often included cultures derived from different mutagenic treatments. Conversely, in most cases, cultures developed through the same mutagenic treatment grouped into different clusters. Thus, grouping of mutants derived from different mutagenic treatments into genetic clusters did not show any definite and regular pattern, which corroborates the findings of Mohapatra *et al.* (1983 and 1987), Mishra (1995) and Sarma and Talukdar (1999). The 16 cultures developed from each of the gamma-rays, EMS and NG treatments grouped into 4,6 and 6 different clusters, respectively. Thus, treatment with all the three mutagens was effective in inducing diversified changes in the quantitative traits.

Table 3 : Average intra-cluster and inter-cluster D² values for the genetin clusters in mutants of greengram variety Pusa Vishal

Cluster No.	I	II	III	IV	V	VI	VII	VIII	IX
I	14.21	22.9	32.3	22.5	50.6	42.2	67.4	44.2	29.1
II		17.63	38.6	27.6	30.1	43.9	56.5	22.9	53.7
III			16.73	26.3	55.0	21.7	34.7	48.1	38.8
IV				14.75	56.9	47.4	66.5	48.4	50.6
V					-	39.7	53.8	24.4	79.4
VI						-	30.2	51.8	28.8
VII							-	39.1	79.7
VIII								-	85.2
IX									-

Table 4 : Mean values for nine characters in the different genetic clusters in mutants greengram variety Pusa Vishal

Cluster No.	No.of entries	Days to flowering	Days to maturity	Plant height (cm)	Bra./ plant	Clu./ plant	Pods/ plant	Seeds/ pod	100 seed w.t (g)	Yield/ plant (g)
I	15	34.29	55.80	38.85	1.10	3.50	8.07	8.17	3.74	2.47
II	17	37.84	57.39	37.43	1.13	3.46	8.22	8.65	3.33	2.37
III	10	33.87	53.23	33.02	1.13	3.57	9.42	8.84	3.58	2.88
IV	2	33.50	52.50	34.82	1.15	3.45	7.63	8.51	3.13	2.09
V	1	37.00	59.67	39.33	1.67	3.97	9.47	9.34	3.26	3.18
VI	1	35.33	55.33	31.33	1.27	3.90	9.00	9.73	4.11	3.29
VII	1	34.67	57.33	23.40	1.00	2.93	10.00	8.39	3.21	2.77
VIII	1	37.33	58.67	35.67	1.00	3.03	9.47	8.77	3.07	2.64
IX	1	34.00	55.33	36.77	1.10	3.20	7.33	8.88	4.71	3.12

The intra-cluster divergence (Av. D²) in the four multi-culture clusters ranged from 14.21 to 17.63 (Table 3). The inter-cluster divergence among the clusters ranged from 21.7 (III and IV) to 85.20 (VIII and IX). A close examination of inter-cluster divergence revealed that the clusters, I, II, III and IV were close clusters, while cluster IX was widely diverse from all other clusters.

From examinations of character means of different clusters (Table 4), it was observed that the clusters showed wide-differences with respect to different traits. On the basis of inter-cluster divergence and character mean values of clusters, Misra (1986), Miranda *et al.* (1999) and Raje and Rao (2001) have suggested crosses which are expected to produce high yielding segregants in greengram. In this study, the three highest yielding clusters were cluster VI (PVE 2-1), cluster V (PVN 1-2) and cluster IX (PVN4-2) each represented by one culture. These clusters possess moderate to high inter-cluster divergence and also wide differences in direct yield component traits like clusters/plant, pods/plant, seeds/pod and 100-seed weight. Thus, the crosses, PVE 2-1 x PVE 1-2, PVN 2-1x PVN 4-2, and PVN 1-2 and PVN 4-2 are excepted to produce more segregants with higher yield.

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Selection of Parents for Chickpea Breeding Through Genetic Variability and Divergence Studies

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ABSTRACT

Choice of parents for breeding chickpea cultivars suitable for Andhra Pradesh was made based on variability and genetic divergence studies. Fifty one genotypes of chickpea, collected from different geographic regions were studied for eight important yield and yield related traits. Of the eight characters considered, maximum coefficient of variability was observed for grain yield per plant followed by number of pods per plant and 100-seed weight. Following nonhierarchical Euclidean cluster analysis, all the fifty one genotypes were grouped into nine clusters. Cluster IX had maximum number of genotypes (14) and cluster VII had only one genotype (ICCV 94305). The clustering pattern indicated that geographic diversity does not necessarily represent genetic diversity in the population of Chickpea studied. Maximum intra-cluster distance was found in cluster III. Similarly, maximum inter-cluster distance was found between cluster I and VIII followed by cluster VI and VII. Hybridization among the genotypes of these diverged clusters is suggested to produce high frequency of transgressive segregants and genetic variability in generations.

Key words : Chickpea, Variability, Genetic Divergence

Chick Pea (*Cicer arietinum L.)* is one of the most important pulse crops of India and of late, its area is rapidly increasing in Andhra Pradesh. In view of increasing demand of this crop, there is immediate need to breed more productive location specific varieties in chickpea. To meet this objective, selection of genetically diverse parents is necessary to produce transgressive segregants Indigenous and exotic genotypes collected from different eco-geographic origin have better potential to create more variability and productive genotypes specific to different niches. Hence, the present study was carried out to assess the variability and genetic divergence among the genotypes selected from different eco-geographic regions of India and abroad and to select the suitable genotypes as parents in chickpea breeding programme.

MATERIAL AND METHODS

The experimental material consisted of 51 lines, selected from working germplasm of Regional Agricultural Research Station, Lam and International Crops Research Institute for Semi Arid Tropics (ICRISAT) gene bank. These lines were evaluated in randomized block design with two replications at Regional Agricultural Research Station, Lam, Guntur during *rabi* 2000-01. Each plot consisted of single row of 4 m, length spaced at inter-and intra-row spacing of 30 cm x 10 cm. Recommended package of practices were followed to raise a good crop. Five competitive plants were selected randomly from each plot for recording observations on days to 50% maturity, plant height (cm), number of branches per plant, number of pods per plant, pod length, 100-seed weight (g) and grain yield per plant (g).

Table 1 : Estimates of mean, range and phenotypic coefficient of variation for eight characters in chickpea

S.No.	Character	Mean	Range	PCV (%)
1	Days to 50% flowering	53.49	31-86	19.40
2	Days to 50% maturity	86.12	65-113	12.39
3	Plant height (cm)	36.73	21.4-64.3	21.69
4	Number of braches per plant	4.78	2.5-7.9	30.03
5	Number of pods per plant	24.65	1.3-49.3	48.53
6	Pod length(cm)	1.31	0.6-2.1	28.56
7	100-seed weight(g)	14.52	15.8-29.6	35.07
8	Grain Yield per plant(g)	11.76	1.4-27.9	67.48

Table 2 : Distribution pattern of 51 diverse genotypes of chickpea in different clusters

S.No.	Cluster No.	No.of genotypes	Genotypes					
1	I	3	ICCV2	ICCV96029	ICCV96030			
2	II	12	ICC2626	ICC14080	ICC3296	ICC 3967	ICC2945	ICC15964
			ICC 7532	ICC2373	ICC453	ICC4154	ICC4926	ICC8450
3	III	8	ICC 2663	ICC3671	ICC14335	ICCV92926	LBeG4	ICCV93118
			ICCV92338	ICC16854				
4	IV	2	ICC8927	ICC8926				
5	V	5	ICC11361	ICCV37	Annegiri	ICCV10	ICCV96022	
6	VI	4	ICC97	ICC5188	ICC16460	ICC12430		
7	VII	1	ICCV94305					
8	VIII	2	ICC1772	ICC5136				
9	IX	14	ICC9921	ICC1564	ICC6478	ICC12236	ICC2402	ICC432
			ICC16205	ICC5680	PG81-1-1	ICCV89220	ICCV93055	ICCV89224
			LBeG-3	Jyothi				

The data were subjected to standard statistical procedures to estimate mean, range and coefficient of variation. The Euclidean cluster analysis (Spark, 1973) was carried out to estimate the intra-and inter-cluster distances and to group the genotypes into different clusters. The whole statistical analysis was carried out using SPAR computer software developed at Indian Agricultural Research Institute, New Delhi.

RESULTS AND DISCUSSION

Analysis of variance indicated significant variation among the 51 lines evaluated for each of the characters. A wide range of variability was noticed for different agronomic and economic traits. The estimates of mean, range and coefficient of variation are given in Table 1. The maximum coefficient of variability was observed for grain yield per plant (67.48%), followed by number of pods per plant (48.53%) and 100-seed weight (35.07). Based on divergence and magnitude of D^2 values, 51 genotypes representing different eco-geographic origins were grouped into 9 clusters (Table 2). The number of genotypes per cluster ranged from 1to 14. The distribution of different genotypes among

Table 3 : Estimates of average intra-cluster (bold) and inter-cluster distances for 9 clusters involving 51 genotypes of chickpea

Cluster No.	I	II	III	IV	V	VI	VII	VIII	IX
I	**1.28**	3.55	2.67	6.23	3.26	5.64	3.93	6.90	2.99
II		**1.54**	2.89	4.25	3.50	2.61	4.88	3.68	2.23
III			**1.77**	4.56	3.21	4.44	3.45	5.22	2.98
IV				**1.21**	6.48	4.90	6.32	3.76	5.77
V					**1.03**	5.23	3.20	5.63	2.96
VI						**1.36**	6.74	3.14	4.17
VII							**0.00**	6.61	4.89
VIII								**1.59**	5.32
IX									**1.34**

Table 4 : Clusterwise mean values of 8 characters of 51 genotypes of chickpea

		Character							
S.No.	Cluster	Days to 50% flowering	Days to 50% maturity	Plant height (cm)	No.of branches/ plant	No.of pods/ plant	Pod length (cm)	100-Kernel weight (g)	Yield/ plant (g)
1	I	34.17	68.00	33.87	4.23	32.17	1.65	14.93	9.28
2	II	55.17	88.29	38.86	4.43	20.21	1.08	11.70	8.62
3	III	51.31	83.88	36.55	4.32	23.85	1.80	20.78	9.00
4	IV	67.00	99.00	62.90	3.30	7.30	1.62	15.65	1.50
5	V	49.10	80.30	31.82	7.65	38.94	1.48	15.78	11.67
6	VI	69.62	102.50	29.50	3.88	8.85	1.00	9.67	3.71
7	VII	46.00	69.00	42.00	7.50	34.00	1.60	27.65	2.15
8	VIII	79.00	108.00	48.05	6.20	5.72	1.02	12.08	5.12
9	IX	49.36	83.07	33.71	4.51	31.24	1.17	13.46	21.98

the characters revealed that cluster IX(14) followed by cluster II (12) had maximum number of genotypes. The cluster VII was unique, having single line (ICCV 94305). Further, the grouping of genotypes did not show any relationship between genetic divergence and geographic diversity. The genetic diversity among the genotypes may be due to factors like history of selection, heterogenity, selection under diverse environments and genetic drift. Therefore, for hybridization, the selection of parents should be based on genetic diversity besides *per-se* performance and empirical knowledge of the breeder. The intra-cluster values varied from 0.00 to 1.77 (Table 3). Maximum intra-cluster distance was found in cluster III (1.77) followed by cluster VII (1.59). Maximum inter-cluster distance existed between cluster I and VIII followed by clusters VI and VII, VII and VIII and IV and V. Hence, hybridization between genotypes of these cluster is suggested. The minimum inter-cluster distance was observed between cluster II and IX. As suggested by Bhatt (1970), the mean statistical distance may also be considered arbitrarily as a guide line and crosses between parents belonging to different clusters may be attempted.

The cluster means for each character are presented in Table 4. The cluster IX had maximum grain yield. The cluster I had minimum number of days to 50% flowering and 50% maturity. Similarly, cluster V had shown maximum number of branches per plant and number of pods per plant. The genotypes (ICCV 2, ICCV 96029 and ICCV 96030) of the cluster I for earliness and the genotypes (ICC 11361, ICCV37, Annegiri, ICCV 10 and ICCV 96022) of cluster V for number of branches per plant and number of pods per plant can be utilized as donor parents for enhancing the yield of other diverse genotypes. Such crosses may show relatively good amount of heterosis in F1 and high frequency of transgressive segregants and genetic variability in subsequent generations. However, the crosses with local and widely adapted varieties like Annegiri, Jyothi and ICCV 37 are also worth to exploit yield potential in chickpea breeding programme in Andhra Pradesh.

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Per Se Performance of Parents and Hybrids in Maize for Grain Yield Characters

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ABSTRACT

Per Se performance of 45 hybrids that resulted from 10 parents crossed in a diallel fashion excluding reciprocals was studied for 12 characters. Maximum grain yield per plant was recorded by the cross P_7 x P_9. The crosses which included P_1, P_7 and P_{10} as parents showed significant increase in grain yield, plant height, chlorophyll content, ear height, leaf area index, anthesis-silking interval and total biomass.

Key words : *Per Se* performance, Hybrid, Maize

The success of any crop breeding programme depends on the choice of parents based on *Per se* performance. The selected genotypes can be used either for the exploitation of heterosis or recombination breeding. Parents with good *per se* performance are exposed to yield desirable recombinations in the segregating generation and the potentiality of such genotypes will also reflect in the performance of hybrids. Because of the above advantages certain maize genotypes and their resultant hybrids were evaluated based on mean *per se* performance.

MATERIAL AND METHODS

Ten maize inbreds *viz.*, P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9 and P_{10} were crossed in a diallel fashion excluding reciprocals at Agricultural Research Station, Amberpet, Hyderabad during *kharif*, 2001 and the resultant 45 hybrids along with the parents and checks were raised in a college farm randomized block design in three replications at College of Agriculture, Rajendranagar, Hyderabad during *rabi*, 2001-2002. Data on days to 50% tasselling, days to 50% silking, days to 50% maturity, anthesis-silking interval, effective kernel filling period, total biomass and grain yield were recorded on whole plot basis, while data on other characters were recorded on 10 randomly selected plants and later averaged. The data were subjected to analysis of variance to assess the treatment differences for the various characters (Panse and Sukhatme, 1961).

RESULTS AND DISCUSSION

Analysis of variance for 12 characters is given in Table 1. There is a significant difference between the genotypes (parents and hybrids) for all the characters studied. The mean performance of parents and top ten crosses with highest *per se* performance are given in Table 2. Plant height and ear height in the parents ranged from 156.60 cm (P_7) to 110.78 cm (P_5) and 89.36 cm (P_7) to 42.96 cm (P_5), respectively. Among the hybrids P_7 x P_{10} recorded the maximum plant height (222.40 cm) and P_6 x P_7 recorded the maximum ear height (118.16 cm). The parental plant height mean was 128.77 cm while that of the hybrids was 180.35 cm. As many as 21 hybrids recorded significant increase in grain

Table 1 : Analysis of variance for grain yield and physiological parameters

Source of variation	d.f	Mean Squares											
		Days to 50% tasselling	Days to 50% silking	Days to 50% maturity	Plant height (cm)	Ear height (cm)	Anthesis -silking interval (days)	Effective kernel filling period (days)	Tassel length (cm)	Chlorophyll content (mg/g)	Leaf area index (LAI)	Total biomass (kg/plot)	Grain yield (kg/plot)
Replications	2	0.313	0.063	0.190	24.200**	3.520**	0.156	0.008	0.586	0.130	0.362	0.207	0.532
Genotypes	54	58.36**	57.18**	82.34**	210.30**	765.00**	6.68**	22.81**	44.25**	7.71**	61.50**	13.08**	1.54
Error	108	1.343	1.342	2.332	3.617	9.546	0.665	1.346	2.111	0.980	2.213	1.185	0.423
SE		0.702	0.791	1.348	1.011	2.237	0.362	0.459	0.840	0.039	0.630	0.549	0.153
CD at 5%		1.001	1.067	2.207	1.913	4.531	0.882	0.917	1.763	0.127	1.341	1.009	0.367
CD at 1%		1.321	1.396	2.613	2.118	5.607	1.002	1.213	2.138	0.195	1.713	1.444	0.459

* Significant at 5% level ; ** Significant at 1% level

yield over the hybrid mean. Among the parents, a wide variation for days to 50% tasselling, days to 50% silking, days to 50% maturity, anthesis-silking interval, effective kernel filling period and tassel length were observed, the range being 85.26 (P_3) to 71.67 (P_8), 89.26 (P_3) to 75.45 (P_7), 121.60 (P_3) to 108.67 (P_5), 4.62 (P_3) to 1.66 (P_5), 35.67 (P8) to 31.50 (P_3) and 3 1.33 (P_7) to 20.33 (P_5), respectively. Among the hybrids P_6 x P_7 recorded the highest value for days to 50% tasselling (75.77), days to 50% silking (78.66), days to 50% maturity (105.67), effective kernel filling period (26.60 days) and tassel length (30.83 cm). The hybrid (P_7 x P_{10}) recorded maximum days for anthesis-silking interval (6.66 days) which exceeded the hybrid mean (3.64 days).

Chlorophyll content is another important character which contributes much to the grain yield (Adhikari *et al.,* 1989). The parental value ranged from 1.733 mg/g (P_7) to 0.943 mg/g (P_4). The cross P_6 x P_7 had the maximum chlorophyll content (2.73 mg/g). Total biomass is also one of the important characters which contributes much to the grain yield. There was a high degree of variation for this character among the parents. The parental mean ranged from 2.11 kg (P_7) to 970 g (P_4). Among the hybrids the cross P_1 x P_9 recorded the maximum total biomass of 3.57 kg. Among the parents, a wide variation for leaf area index was observed, the range being 1.42 (P_8) to 0.64 (P_4). The hybrid (P_1 x P_3) recorded the maximum leaf area index (2.62, which exceeded the hybrid mean (1.93). Grain yield per plot is an important character for commercial exploitation in maize. The parents showed wide variation for this character, the range being 2.82 kg (P_7) to 1.25 kg (P_4). The hybrid P_7 x P_9 recorded the highest grain yield among the cross combinations studied.

Based on the number of times a genotype is occurring as one of the parents for the hybrid recording high values, those genotypes were

Table 2 : Mean performance of parents and top ten first generation hybrids with the highest *per se* performance for grain and physiological parameters

		Mean Squares										
Entries	Days to 50% tasselling	Days to 50% silking	Days to 50% maturity	Plant height (cm)	Ear height (cm)	Anthesis -silking interval (days)	Effective kernel filling period (days)	Tassel length (cm)	Chlorophyll content (mg/g)	Leaf area index (LAI)	Total biomass (kg/plot)	Grain yield (kg/plot)
P_1	81.66	85.36	117.38	120.93	47.16	3.66	31.59	21.33	1.12	0.91	1.35	1.81
P_2	80.19	82.60	115.75	126.83	50.86	2.33	32.67	21.83	1.03	0.84	1.26	1.67
P_3	85.26	89.26	121.60	120.70	63.03	4.66	31.50	21.20	1.05	0.85	1.27	1.70
P_4	78.46	82.35	114.65	114.55	51.26	3.66	31.66	20.80	0.94	0.64	0.97	1.25
P_5	74.56	76.37	108.67	110.78	42.96	1.66	31.55	20.33	1.08	0.88	1.31	1.75
P_6	80.60	83.67	116.40	120.83	63.23	2.66	32.67	21.27	1.03	0.85	1.26	1.68
P_7	72.30	75.45	111.29	156.60	89.36	2.66	35.60	31.33	1.73	1.40	2.11	2.82
P_8	71.67	75.60	111.66	145.10	78.80	3.66	35.67	26.30	1.14	1.42	1.40	1.84
P_9	76.60	78.66	114.75	141.53	72.46	1.66	35.56	23.33	1.29	1.08	1.63	2.17
P_{10}	79.60	83.66	115.66	128.90	67.20	3.66	31.60	22.29	1.38	1.17	1.76	2.34
P_7xP_9	67.63	73.61	99.60	197.88	84.93	6.66	25.42	31.79	2.83	2.37	3.57	4.76
P_7xP_{10}	69.70	75.39	101.69	222.40	89.56	6.66	25.40	24.30	2.63	2.31	3.32	4.65
P_3xP_{10}	70.66	72.66	99.60	201.03	86.86	2.33	26.60	23.83	2.68	2.26	3.38	4.53
$P_6x P_7$	75.67	78.66	105.67	210.03	118.16	3.33	26.60	30.83	2.73	2.25	3.41	4.52
P[illegible]xP[illegible]	70.50	74.67	100.37	189.13	71.13	4.66	24.53	28.33	2.68	2.23	3.35	4.46
P_1xP_{10}	68.56	75.57	100.03	166.83	75.76	6.33	25.19	27.32	2.58	2.04	3.02	4.29
$P_1 x P_4$	72.66	74.68	102.22	172.50	77.96	2.66	27.59	27.37	2.50	2.02	3.01	4.27
P_6xP_8	68.38	70.57	100.69	190.03	80.14	3.66	24.55	29.37	2.51	2.09	3.01	4.18
P_1xP_3	67.57	71.59	100.39	157.86	69.31	4.33	28.60	26.33	2.48	2.62	2.93	4.12
P[illegible]xP_7	69.96	72.66	99.66	211.03	107.90	3.66	20.50	30.29	2.03	1.93	2.51	4.10
Mean of parents	79.09	81.29	114.78	128.77	62.64	3.03	32.98	23.00	1.18	1.04	1.57	1.91
Mean of hybrids	69.50	71.71	103.57	180.35	83.46	3.64	29.73	27.27	2.33	1.93	2.87	3.85
DHM 105 (check)	66.67	69.67	105.34	194.36	76.50	3.33	30.10	27.23	2.41	2.13	2.95	3.85
Grand mean	73.79	76.50	109.18	154.56	73.05	3.33	31.35	25.39	1.73	1.47	2.15	2.88
SE	0.702	0.791	1.348	1.011	2.237	0.362	0.459	0.840	0.039	0.630	0.549	0.153
CD at 5 %	1.001	1.067	2.207	1.913	4.531	0.882	0.917	1.763	0.127	1.341	1.009	0.367
CD at 1%	1.321	1.396	2.613	2.118	5.607	1.002	1.213	2.138	0.195	1.713	1.444	0.459

identified as donors for different plant attributes, P_1, P_7 and P_{10} for grain yield, plant height, chlorophyll content, ear height, leaf area index, anthesis silking interval and total biomass; P_9 for effective kernel filling period; P_6 for days to 50% tasselling, days to 50% silking and days to 50% maturity. These genotypes can be used as parents in the hybridization programme for improving grain yield and other related characters.

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Correlation and Path Coefficient Analyses in Drought Tolerant Rice Cultures for Yield

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ABSTRACT

In this study, seventeen genotypes were used to find the characters to be considered to improve the yield of drought tolerant rice cultures. Correlation studies revealed that selection based on five characters namely, plant height, days to 50 per cent flowering, first flowering, number of fibrous roots per plant and root length could improve yield. Further partitioning of genotypic correlation through path coefficient analysis revealed that selection should be based on number of fibrous roots per plant, days to first flowering and root length to improve yield.

Key words : Correlation, Path Analysis, Drought, Rice

Rice is a vital crop of entire world population. In rice, global loss due to drought was estimated as high as $ 3.51 billion annually (Michael Gomaz *et al.*, 2002). In India, 58% of the rice growing areas are under rainfed condition. Drought stress, therefore, is an important limitation to rice production in India, particularly among low income and subsistence farmers. Unless there is in built tolerance for drought, increasing grain yield will be difficult. Hence there is a need to improve the genetic yield potential of drought tolerant rice genotypes. In this study, attempt has been made to understand the association of yield with its component traits through correlation and path coefficient analyses.

MATERIAL AND METHODS

Present experiment was done at Agricultural College and Research Institute, Killikulam. This study comprised seventeen including a drought susceptible genotype replicated thrice in randomized block design with inter-row and intra-row spacing of 20 cm X 15 cm. Five plants were selected randomly to record data on plant height, number of fibrous roots per plant, days to first flowering, days to 50 per cent flowering, root length, productive tillers per plant, root volume, harvest index, number of grains per panicle, root weight, panicle length, 1000-grain weight, length and breadth ratio of grain, straw yield, relative water content of leaf, boot leaf area and single plant yield. Correlation studies were carried out as suggested by Johnson *et al.*, (1955) and path analysis by Wright (1921) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

Single plant yield had positive significant correlation with all the characters except root length, 1000-grain weight, length and breadth ratio of grain and relative water content of leaf at both phenotypic and genotypic level. Similarly, highly significant positive correlation of grain yield per plant was observed with productive tillers per plant, harvest index and 1000 grain weight by Lu *et al.* (1989) ; Sampath *et al.* (1989) ;

Table 1 : Estimates of genotypic (G) and phenotypic (P) correlation coeffcients between yield and yield components in drought tolerant rice cultures

Characters		Fibrous roots/plant	First flowering	50% flowering	Root length	Productive tillers/plant	Root volume	Harvest index	Grains per panicle
Plant height (cm)	G	0.532**	0.724**	0.632**	0.335	-0.166	0.399*	0.324	0.657**
	P	0.417*	0.656**	0.548**	0.239	0.007	0.394*	0.247	0.588**
Fibrous roots / plant (no)	G		0.472**	0.478**	0.455**	0.437**	0.640**	0.118	0.703**
	P		0.425*	0.424*	0.389*	0.253	0.541**	0.149	0.608**
First flowering (days)	G			0.983**	0.817**	-0.297	0.772**	0.088	0.803**
	P			0.963**	0.693**	-0.210	0.738**	0.096	0.771**
50% flowering (days)	G				0.888**	-0.325	0.783**	-0.004	0.801**
	P				0.708**	-0.268	0.745**	-0.015	0.782**
Root Length (cm)	G					-0.590**	0.753**	-0.252	0.858**
	P					-0.332	0.636**	-0.153	0.688**
Productive tillers/plant (no)	G						-0.033	0.363*	-0.397*
	P						0.020	0.322	-0.260
Root Volume (cc)	G							0.072	0.715**
	P							0.052	0.688**
Harvest Index	G								-0.092
	P								-0.089

**Significant at 1% level * Significant at 5% level

John F. Kennedy and Rangasamy (1998) at both phenotypic and genotypic level.

Among the sixteen yield components taken for study, five characters *viz.,* plant height, number of fibrous roots per plant, days to first flowering, days to 50 per cent flowering and root length had significant positive correlation with more number of characters including yield (Table 1). Plant height had significant positive correlation with days to 50 per cent flowering as reported by John F. Kennedy and Rangasamy (1998), filled grains per panicle as found by Singh *et al.* (2000) and Satya Priya Lalitha and Sreedhar (1996) and panicle length as reported by Shivani and Sree Rama Reddy (2000). Significant positive correlation of days to 50 per cent flowering was observed with number of grains per panicle as suggested by Yolanda and Vijendra Das (1995), Panicle lengths reported by Ganesan *et al.* (1998).

Further partitioning of genotypic correlation of selected five characters into direct and indirect effects was done through path coefficient analysis (Table 2). Among the five characters selected for improving the grain yield, plant height and days to 50 per cent flowering had negative direct effects with yield. Similar results were obtained by Shivani and Sree Rama Reddy (2000). This implied that maximum number of significant positive correlation obtained with plant height and days to 50 per cent flowering for yield was through other components. Plant height had negative indirect effect through 1000-grain weight and harvest index as reported by Shivani and Sree Rama Reddy (2000). Days to 50 per cent flowering had negative indirect effect via plant height as recorded by Shivani and Sree Rama Reddy (2000). Remaining three selected characters namely number of fibrous roots per plant, days to first flowering and root length had

Table 1.

Characters		Root weight	Panicle length	1000 grain wieght	LB ratio of grain	Straw yield	Relative water content of leaf	Boot leaf Area	Single plant yield
Plant height	G	0.174	0.677**	0.462**	-0.519**	0.500**	0.161	0.633**	0.682**
	P	0.146	0.578**	0.407*	-0.469**	0.406*	0.086	0.574**	0.548**
Fibrous roots / plant	G	0.568**	0.693**	-0.106	-0.072	0.630**	0.326	0.348*	0.683**
	P	0.540**	0.513**	-0.084	-0.079	0.535**	0.201	0.262	0.603**
First flowering	G	0.618**	0.917**	0.325	0.141	0.707**	-0.252	0.820**	0.685**
	P	0.580**	0.727**	0.313	0.141	0.626**	-0.186	0.756**	0.609**
50% flowering	G	0.722**	0.942**	0.200	0.305	0.690**	-0.297	0.801**	0.605**
	P	0.688**	0.750**	0.199	0.301	0.629**	-0.212	0.745**	0.512**
Root Length	G	0.799**	0.787**	-0.148	0.448**	0.664**	0.165	0.724**	0.399*
	P	0.606**	0.551**	-0.121	0.341*	0.463**	-0.083	0.606**	0.285
Productive tillers/plant	G	-0.076	-0.127	0.189	-0.135	0.143	0.388*	-0.654**	0.416*
	P	-0.058	-0.073	0.102	-0.116	0.119	0.276	-0.395*	0.370*
Root Volume	G	0.820**	0.827**	0.242	0.300	0.698**	-0.064	0.631**	0.684**
	P	0.756**	0.704**	0.236	0.289	0.627**	-0.017	0.605**	0.586**
Harvest Index	G	-0.171	-0.147	0.272	-0.477**	-0.285	0.209	0.084	0.442**
	P	-0.158	-0.095	0.205	-0.400**	-0.296	0.136	0.026	0.558**
Grains per panicle	G	0.652**	0.854**	-0.014	0.029	0.676**	-0.030	0.821**	0.560**
	P	0.614**	0.718**	-0.010	0.030	0.634**	-0.016	0.783**	0.477**
Root weight	G		0.831**	-0.027	0.597**	0.695**	-0.193	0.544**	0.503**
	P		0.676**	-0.018	0.557**	0.657**	0.142	0.493**	0.429*
Panicle length	G			0.311	0.261	0.888**	-0.043	0.744**	0.685**
	P			0.268	0.214	0.687**	-0.044	0.675**	0.509**
1000 grain weight	G				-0.210	0.207	-0.062	0.309	0.360*
	P				-0.210	0.207	-0.046	0.300	0.315
LB ratio of grain	G					0.177	-0.442**	-0.001	-0.210
	P					0.168	-0.288	-0.004	-0.199
Straw yield	G						-0.098	0.450**	0.735**
	P						-0.028	0.405*	0.616**
Relative water content of leaf	G							-0.102	0.087
	P							-0.113	0.112
Boot leaf area	G								0.463**
	P								0.362*

**Significant at 1% level * Significant at 5% level

positive direct effects on yield. Hence for improving yield of drought tolerant rice cultures much weightage should be given for these three characters.

Genotypic correlation of seventeen genotypes for seven characters indicated selection based on plant height, days to 50 per cent flowering, days to first flowering, number of fibrous roots per plant and root length could improve yield. Further, partitioning of genotypic correlation through path analysis suggested that selection should be based on number of fibrous roots per plant, days to first flowering and root length to improve yield of drought tolerant rice cultures.

Table 2 : Direct and indirect effects of sixteen characters on single plant yield in drought tolerant rice cultures

Characters	Plant height	Fibrous roots/ plant	First flowering	50% flowering	Root length	Productive tillers/ plant	Root volume	Harvest index
Plant height	**-0.255**	0.147	0.332	-0.197	0.105	-0.006	-0.067	0.179
Fibrous roots / plant	-0.133	**0.280**	0.216	-0.149	0.142	0.015	-0.108	0.065
First flowering	-0.184	0.132	**0.459**	-0.306	0.256	-0.010	-0.130	0.049
50% flowering	-0.161	0.134	0.451	**-0.311**	0.278	-0.011	-0.132	-0.002
Root Length	-0.086	0.128	0.375	-0.276	**0.313**	-0.020	-0.127	-0.139
Productive tillers/plant	0.042	0.123	-0.136	0.101	-0.184	**0.034**	0.005	0.200
Root Volume	-0.102	0.180	0.353	-0.244	0.235	-0.001	**-0.169**	0.039
Harvest Index	-0.083	0.033	0.040	0.001	-0.079	0.012	-0.012	**0.553**
Grains per panicle	-0.167	0.197	0.368	-0.249	0.268	-0.014	-0.121	-0.051
Root weight	-0.044	0.159	0.283	-0.225	0.249	-0.003	-0.138	-0.095
Panicle length	-0.173	0.194	0.421	-0.293	0.246	-0.004	-0.139	-0.081
1000 grain weight	-0.118	-0.029	0.149	-0.062	-0.046	0.006	-0.041	0.150
LB ratio of grain	0.132	-0.020	0.065	-0.095	0.139	-0.005	-0.051	-0.263
Straw yield	-0.127	0.176	0.324	-0.215	0.207	0.005	-0.118	-0.157
Relative water content of leaf	-0.041	0.092	-0.116	0.092	-0.052	0.013	0.011	0.115
Boot leaf area	-0.161	0.098	0.376	-0.249	0.227	-0.022	-0.106	0.046

Diagonal values in bold represent the direct effects Residual effect - 0.0525

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Table 2 : (Contd.) Direct and indirect effects of sixteen characters on single plant yield

Characters	Grains per penicle	Root weight	Panicle length	1000 grain weight	LB ratio of grain	Straw yield/ ant	Relative water content of leaf	Boot leaf area	Genotypic correlation coefficient with single plant yield
Plant height	-0.216	0.033	0.016	0.046	0.192	0.364	-0.013	0.023	0.682**
Fibrous roots / plant	-0.231	0.109	0.017	-0.011	0.027	0.459	-0.027	0.012	0.683**
First flowering	-0.264	0.118	0.022	0.033	-0.052	0.515	0.021	0.029	0.685**
50% flowering	-0.264	0.138	0.023	0.020	-0.112	0.502	0.024	0.029	0.605**
Root Length	-0.282	0.153	0.019	-0.015	-0.165	0.483	0.014	0.026	0.399*
Productive tillers/plant	0.131	-0.015	-0.033	0.019	0.049	0.104	-0.032	-0.023	0.416*
Root Volume	-0.235	0.157	0.020	0.024	-0.111	0.508	0.005	0.023	0.684**
Harvest Index	0.030	-0.033	-0.004	0.027	0.176	-0.207	-0.017	0.003	0.442**
Grains per panicle	**-0.329**	0.125	0.021	-0.001	-0.011	0.492	0.002	0.029	0.560**
Root weight	-0.215	**0.191**	0.020	-0.002	-0.220	0.506	0.016	0.019	0.503**
Panicle length	-0.281	0.159	**0.024**	0.031	-0.096	0.646	0.004	0.028	0.685**
1000 grain weight	0.005	-0.005	0.008	**0.100**	0.077	0.151	0.005	0.011	0.360*
LB ratio of grain	-0.009	0.114	0.006	-0.021	**-0.369**	0.129	0.036	-0.001	-0.210
Straw yield	-0.223	0.133	0.021	0.021	-0.065	**0.728**	0.008	0.016	0.735**
Relative water content of leaf	0.009	-0.037	-0.001	-0.006	0.163	-0.071	**-0.082**	-0.003	0.087
Boot leaf area	-0.270	0.104	0.019	0.031	0.001	0.328	0.008	**0.036**	0.463**

Diagonal values in bold represent the direct effects

Residual effect - 0.0525

* and ** significant at 5% and 1% level, respectively

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Combining Ability Studies in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

An investigation to assess the magnitude and direction of combining ability of four cytoplasmic male sterile lines and ten fertility restorers in sunflower revealed that the lines, DCMS 36A for days to 50 per cent flowering and days to maturity, DCMS 41A for oil content and DCMS 42A for head diameter, number of seeds per plant, 100 seed weight and seed yield per plant were good general combiners. Among the testers, DRS 9, DRS 16 and DRS 3 were found to be good male donors for head diameter, number of seeds per plant and seed yield per plant. The cross combination DCMS 42A x RHA 272-1, DCMS 37A x DRS 12 and DCMS 42A x DRS 9 were found to be best combinations for days to 50 per cent flowering, seed yield per plant and oil content, respectively. Non additive gene action was predominant for all the characters studied. The maintainers of these CMS lines and good combiners of male lines could be used in creating dynamic population for recurrent selection.

Key words : Combining Ability, Sunflower

Sunflower is one of the most important oilseed crops of India. The discovery of cytoplasmic male sterility (CMS) (Leclercq, 1966) in France and fertility restoration (Kinnan,1970) in USA has provided the required break through for heterosis breeding in sunflower. As a result, plant breeders have extensively used and exploited heterosis to improve seed and oil yield in sunflower. Hybrids are generally more vigorous, uniform, self fertile and also resistant to important foliar diseases (Seetharam, 1980). In a systematic breeding programme, it is essential to identify superior parents for hybridization and crosses to expand the variability reservoir for selection of superior genotypes. In the present study an attempt was made to assess combining ability and gene action governing quantitative traits in sunflower for four cytoplasmic male sterile lines and ten fertility restorer lines by employing line x tester analysis.

MATERIAL AND METHODS

Four cytoplasmic male sterile lines and ten fertility restorer lines were mated in line x tester fashion to generate 40 hybrids. These crosses along with their 14 parents were grown in randomized block design with three replications. The crossing programme was carried out during *kharif* 2003 and the evaluation of the crosses and their parents was done during *rabi* 2003-04. Each entry was grown in a single row of 3 m length with inter-row spacing of 60 cm and intra-row spacing of 30 cm. A standard package of practices were followed for raising the crop. Observations were recorded on five randomly selected plants in each treatment for all replications for nine quantitative traits *viz.*, days to 50 per cent flowering, days to maturity, plant height (cm), head diameter (cm), number of seeds per plant, filled seed per cent, 100 seed weight (g), seed yield per plant (g) and oil content

Table 1 : Estimates of general combining ability (*gca*) effects for nine characters in sunflower

Parents	Plant height (cm)	Days to 50% flowering	Days to maturity	Head diameter (cm)	No.of seeds plant	Filled seed per cent	100 seed weight (g)	Seed yield per plant (g)	Oil content (%)
Lines									
DCMS 36B	6.95**	-0.80**	-0.79*	-1.58**	-125.06**	0.65	-0.21**	-5.59**	-2.32**
DCMS 37B	-4.07	1.00**	1.34**	-0.69**	-11.06	0.21	0.25**	1.66**	1.17
DCMS 41B	-6.27**	0.40	-0.43	0.75**	57.32**	-1.85	-0.27**	-0.74	3.39**
DCMS 42B	3.39	-0.60*	-0.13	1.53**	78.80**	0.98	0.22**	4.68**	-2.24**
SE_l	2.24	0.30	0.35	0.16	16.19	1.07	0.07	0.57	0.64
Testers									
DRS 16	-41.57**	-3.42**	-3.83**	3.06**	182.97**	-2.32	0.04	5.96**	-0.13
DRS 9	5.22	0.03	3.05**	2.48**	77.63**	-0.31	0.37**	5.81**	-0.38
DRS 3	-10.65**	-0.13	-0.82	1.49**	86.02**	3.76	0.14	5.88**	-3.47**
DRS 12	-17.52**	1.45**	1.17*	-1.00**	58.50*	-10.09**	0.63**	2.18*	-2.88**
LTRR 341	4.07	-0.80	-1.33*	-1.12**	-20.11	2.40	0.74**	5.65**	-0.84
RCR 8297	29.55**	2.45**	3.80**	-1.25**	-11.42	4.00	-0.55**	-1.34	-0.73
DRS 11	0.26	-4.68**	-5.70**	0.81**	105.83**	4.21	-0.95**	-3.07**	5.03**
DRS 15	-2.48	-3.17**	-3.91**	-3.79**	-195.94**	5.40**	0.22	-4.33**	4.62**
NDLR-1	39.33**	6.70**	5.93**	-0.42	-184.90**	-2.58	0.22	-6.44**	1.52
RHA 272-1	-6.2	1.58**	1.63**	-0.28	-98.59**	-4.47**	-0.86**	-10.30**	-2.73**
SE_l	3.55	0.48	0.55	0.26	25.6	1.70	0.12	0.90	1.01

* Significant at 5 per cent level ** Significant at 1 per cent level

(%). Mean values of the nine characters for different entries were subjected to line x tester analysis (Kempthorne, 1957) to estimate general combining ability, specific combining ability effects and their respective variances.

RESULTS AND DISCUSSION

Analysis of variance indicated that the lines exhibited significant differences among themselves for head diameter, number of seeds per plant, seed yield per plant and oil content, whereas the testers showed significant differences for all the characters studied except for oil content. However, the lines x testers exhibited significant differences among themselves for all the characters studied. Further, crosses were also found to be significantly different from each other for all the characters. It could be because of diverse nature of testers and the significant interaction between lines and testers. The estimates of GCA of 14 parent for nine quantitative characters are furnished in Table 1. Among the lines, DCMS 42A registered highest positive *gca* effects for head diameter, number of seeds per plant, 100 seed weight and seed yield per plant, while for oil content DCMS 41A recorded the highest positive *gca* effect indicating that these lines were good general combiners. Further, DCMS 36A was a good general combiner for earliness as it recorded the highest negative *gca* effects for days to 50 per cent flowering and days to maturity.

Table 2 : Estimates of specific combining ability (*sca*) effects for nine characters in sunflower

Hybrids	Plant height (cm)	Days to 50% flowering	Days to maturity	Head diameter (cm)	No.of seeds plant^{1}	Filled seed per cent	100 seed weight (g)	Seed yield per plant (g)	Oil content (%)
DCMS 36A x DRS 16	-2.03	-1.83	-1.21	0.34	31.06	1.84	0.11	2.62	-0.08
DCMS 36A x DRS 9	8.78	4.05**	7.42**	-1.07*	-33.50	4.38	0.38	2.35	-0.72
DCMS 36A x DRS 3	19.65**	0.55	2.79*	1.72**	132.41**	-2.43	0.32	6.30**	-5.74**
DCMS 36A x DRS 12	20.72**	0.30	-0.21	-1.40**	108.94*	-10.81**	-0.50*	-4.14*	0.68
DCMS 36A x LTRR 341	-10.67	-1.45	-1.71	3.34**	163.01**	0.30	-0.25	4.25*	-0.35
DCMS 36A x RCR 8297	-6.95	-1.20	-3.50**	-3.02**	-267.15**	-2.66	-1.02**	-15.26**	1.51
DCMS 36A x DRS 11	-1.86	-0.57	-0.33	1.29*	48.61	-0.29	0.12	3.34	-1.26
DCMS 36A x DRS 15	-7.72	-2.08*	-2.12	-1.02	38.40	-0.87	0.45	3.20	2.18
DCMS 36A x NDLR-1	-8.72	3.05**	-2.96**	1.42**	-232.61**	0.12	-0.07	-8.84**	-0.74
DCMS 36A x RHA 272-1	-11.20	-0.82	1.83	-1.61**	10.83	10.42**	0.45	6.17**	4.51*
DCMS 37A x DRS 16	-14.23*	1.38	0.66	0.65	-71.04	2.28	-0.47	-5.10**	-1.57
DCMS 37A x DRS 9	-0.77	-1.08	-2.22*	-0.56	-61.37	3.27	-0.39	-4.19*	-2.23
DCMS 37A x DRS 3	-37.83**	-0.92	-3.34**	-0.29	32.91	6.00	-0.97**	-4.32*	5.88**
DCMS 37A x DRS 12	-42.96**	1.50	2.66*	1.21*	110.43*	3.10	0.22	7.70**	7.16**
DCMS 37A x LTRR 341	22.78**	0.75	0.16	-1.65**	-6.96	-2.33	0.47	1.82	-0.82
DCMS 37A x RCR 8297	16.07*	-0.50	3.03**	5.65**	173.35**	-0.63	0.42	8.31**	2.22
DCMS 37A x DRS 11	15.17*	1.63	1.53	-2.19**	-150.56**	-0.94	0.94**	2.46	-2.73
DCMS 37A x DRS 15	18.70**	0.13	1.41	-0.29	75.87	2.59	-0.44	0.79	-0.73
DCMS 37A x NDLR-1	12.05	-2.75**	-1.09	-1.05*	17.84	-6.22	0.27	-0.74	0.50
DCMS 37A x RHA 272-1	11.03	-0.12	-2.80*	-1.47**	-120.47*	-7.13*	-0.06	-6.74**	-7.68**
DCMS 41A x DRS 16	4.79	-0.03	-0.58	-0.94	153.58**	-4.66	0.35	5.62**	4.20*
DCMS 41A x DRS 9	-3.50	0.52	0.55	0.60	3.92	-7.17*	-0.36	-6.30**	-1.17
DCMS 41A x DRS 3	10.08	0.68	2.42*	-0.43	-12.47	-5.02	0.56*	1.96	4.88*
DCMS 41A x DRS 12	13.54	0.10	-2.58*	1.19*	46.05	0.42	-0.12	0.92	0.78
DCMS 41A x LTRR 341	-6.23	1.35	1.92	1.20*	-6.74	4.62	0.06	2.86	-0.38
DCMS 41A x RCR 8297	3.47	1.10	1.80	0.31	-25.70	4.07	0.25	0.83	0.83
DCMS 41A x DRS 11	-4.62	-0.28	-0.70	-1.33*	-70.62	6.23	-0.32	-2.63	-2.69
DCMS 41A x DRS 15	-0.69	-0.28	-1.49	-1.51**	-23.29	2.66	0.30	2.70	-2.94
DCMS 41A x NDLR-1	-13.22	-3.15**	-1.33	1.23*	-25.21	4.31	0.18	2.21	-2.35
DCMS 41A x RHA 272-1	-3.62	-0.03	-0.03	-0.34	-39.52	-5.45	-0.90**	-8.18**	-1.17
DCMS 42A x DRS 16	11.47	0.47	1.13	-0.05	-113.60*	0.54	0.00	-3.15	-2.55
DCMS 42A x DRS 9	-4.52	-3.48**	-5.75**	1.02*	90.94	-0.48	0.38	8.13**	4.12*
DCMS 42A x DRS 3	8.10	-0.32	-1.87	-1.00	-152.85**	1.45	0.08	-3.94*	-5.02*
DCMS 42A x DRS 12	8.70	-1.90*	0.13	-1.00	-265.42**	7.29*	0.39	-4.47*	-8.62**
DCMS 42A x LTRR 341	-5.88	-0.65	-0.37	-2.88**	-149.32**	-2.59	-0.29	-8.93**	1.55
DCMS 42A x RCR 8297	-12.58	0.60	-1.33	-2.95**	119.49*	-0.79	0.36	6.11**	-4.56*
DCMS 42A x DRS 11	-8.69	-0.78	-0.50	2.22**	172.58**	-5.01	-0.74**	-3.18	6.67**
DCMS 42A x DRS 15	-10.29	2.22*	2.21*	2.82**	-90.98	-4.37	-0.30	-6.68**	1.49
DCMS 42A x NDLR-1	9.90	2.85**	5.38**	-1.60**	239.98**	1.79	-0.39	7.36**	2.59
DCMS 42A x RHA 272-1	3.79	0.97	1.00	3.42**	149.17**	2.17	0.50*	8.75**	4.34*
SE$_{ij}$	7.10	0.96	1.11	0.52	51.20	3.40	0.34	1.80	2.02

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 3 : Estimates of general and specific combining ability variance, proportionate gene action and degree in sunflower

	Plant height (cm)	Days to 50% flowering	Days to maturity	Head diameter (cm)	No.of seeds plant	Filled seed per cent	100 seed weight (g)	Seed yield per plant (g)	Oil content (%)
σ^2 gca	20.61	0.47	0.54	0.18	718.79	0.72	0.01	1.59	0.39
σ^2 sca	237.88	2.79	7.71	4.76	19108.04	16.97	0.24	44.49	14.97
σ^2 gca / σ^2 sca	0.08	0.16	0.07	0.03	0.03	0.0	0.05	0.03	0.02
Degree of dominance $\sqrt{\frac{\sigma^2 gca}{\sigma^2 sca}}$	2.40	1.71	2.66	3.60	3.64	3.42	2.92	3.73	4.32

Among the testers DRS 9, DRS 16 and DRS 3 appeared to posses favourable alleles with additive effect for head diameter, number of seeds per plant and seed yield per plant as evident from significant positive *gca* effects of these lines for the above traits. The tester DRS 16 possessed favourable alleles for days to 50 per cent flowering, days to maturity and plant height. This indicates that this particular tester (DRS 16) seemed to possess decreasing alleles with additive effect for head diameter, number of seeds per plant and seed yield per plant. The testers DRS 15 and DRS 11 were found to be the best general combiners for days to 50 per cent flowering, days to maturity, seed yield per plant and oil content, as they recorded the highest significant *gca* effects in desirable direction. It seemed to possess unfavourable alleles for seed yield per plant, revealed from significant negative *gca* effects exhibited by these testers.

The estimates of *sca* effects of 40 hybrids for nine quantitative characters, are presented in Table 2. The *sca* effects were found to be significant for seed yield and yield components. The two parental lines involved in the cross DCMS 42A x DRS 9 and DCMS 42A x DRS 12 exhibited opposite *gca* effects (negative and positive, respectively) for days to 50 per cent flowering, however, both these crosses exhibited significant *sca* effects which might be due to high frequency of dominant alleles for earliness. However, both parental lines in the cross combinations DCMS 41A x NDLR-1 and DCMS 37A x NDLR-1 did not seem to possess favourable genes for earliness. The negative *sca* effects of this combination may be attributed to the favourable epistatic interaction of genes from these two lines.

For all the nine characters under study, the crosses with significant *sca* effects involved parents with high x high, high x low , low x high and low x low *gca* effects. For seed yield per plant the crosses, DCMS 42A X DRS 9 and DCMS 37 Ax DRS 12 involved both parents with high *gca* effects, the crosses DCMS 41A x DRS 16, DCMS 42A x RCR 8297, DCMS 37AX RCR 8297, DCMS 36A x DRS 3, DCMS 42A x NDLR-1, DCMS 36A X LTRR 341 and DCMS 42A x RHA 272-1 involved parents with high x low or low x high *gca* effects and the cross DCMS 36A x RHA 272-1 involved parents with low x low *gca* effects.

The hybrids DCMS 42A X RHA 272-1 and DCMS 37Ax RCR 8297 for seed yield per plant and DCMS 37A x DRS 12 and DCMS 42Ax DRS 11 for oil content recorded highest *gca* effects. The crosses DCMS 37Ax DRS 12 and DCMS 37A x DRS 3 for plant height, DCMS 42A x NDLR-1 and DCMS 37A x RCR 8297 number of seeds per plant, DCMS 36A x RHA 272-1 and DCMS 42A x DRS 12 for filled seed per cent, DCMS 37Ax DRS 11 and DCMS 41A x DRS 3 for 100 seed weight exhibited desired highest *gca* effects.

In general hybrids with significant *sca* effects in the desired direction involved parents with either high x high, high x low or low x high or low x low *gca* effects indicating high performance of these crosses due to additive, dominance or epistatic gene interactions. The results such as high x low cross combinations were earlier reported by Kadkol *et al.* (1984), Giriraj *et al.* (1987) and Limbore *et al.* (1997). In addition, crosses with high *sca* effects involving high x high *gca* effects were also reported by Limbore *et al.* (1997) and low x low by Kadkol *et al.* (1984) and Giriraj *et al.* (1987).

Predominance of dominant gene action was evident from the ratio of GCA to SCA variance of all the characters (Table 3). Non-additive gene action had been reported by earlier workers (Giriraj *et al.,* 1987; Alone *et al.*, 1996; Nirmala *et al.* 1999 and Radhika *et al.,* 2001). However, additive gene action for these traits has also been reported (Sudhakar *et al.,* 1984; Balaji *et al.*, 1997 and Ashok *et al.* 2000).

It is suggested that good combining parents *i.e.* maintainer lines of DCMS 42A and DCMS 36A as well as DRS 16 and DRS 3 for different traits may be utilized in constituting dynamic population, which could be improved through recurrent selection. The most promising parents in the hybrids can be used for hybrid breeding programme.

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Heterosis of Indica / Indica Tropical Japonica Rice Hybrids

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ABSTRACT

A study was conducted on heterosis for yield, yield components and quality characters made over better parent and further, yield heterosis made over standard checks APHR-2 and MTU-1010. It indicated that high levels of heterosis observed for grain yield per plant and filled grain per panicle. However, heterosis for the quality traits was observed to be low. Among twenty three hybrids with more than 20% heterosis for grain yield, eight hybrids exhibited significant and desirable heterobeltiosis for head rice recovery.

Key words : Heterosis, Hybrid Rice, Rice Hybrids

Rice is the principal food crop of Andhra Pradesh. Yield plateaus have been observed in the crop in recent years. Development of hybrid rice has been identified as a potent technological option for breaking the yield plateaus (Siddiq, 1997). Among the rice hybrids yield heterosis was reported to be relatively high for indica / tropical japonica hybrids compared to indica x indica hybrids. However, very low frequency of restorer for indica cyto-sterile lines has been reported in tropical japonica (Khush *et al.*, 1998). The utilisation of indica / tropical japonica derivatives as restorer for WA based indica cytosteriles was suggested by Satyanarayana *et al.* (2002) for high fertility restoration coupled with high levels of heterosis. The present investigation was undertaken in this context to elucidate information on heterosis of the elite indica, tropical japonica derivatives, obtained from the on going restorer improvement programme at Agricultural Research Station, Maruteru.

MATERIAL AND METHODS

The experimental material comprised of 88 hybrids derived from line X tester mating of four WA based indica cyto-steriles with 22 elite indica / tropical japonica derivatives during *Kharif* 2003 at Agricultural Research Station, Maruteru. The hybrids were evaluated along with parents and two checks APHR-2 and MTU1010 in a randomised block design with three replications during *rabi* 2003-2004. Each plot consisted of two rows of 3m length with a intra- and inter-row spacing of 15 x 15 cm. Recommended practices were followed.

Observations on yield, yield component characters were recorded on five random competitive plants for each entry in each replication. In case of females (cytoplasmic male sterile lines), the observations were recorded on their respective maintainer (B) lines. Further, observations on days to 50 per cent flowering, 1000-seed weight, hulling, milling and head rice recovery were recorded on plot basis. Heterosis over better parent and the standard checks was estimated as per Liang *et al.* (1972).

RESULTS AND DISCUSSION

Mean performances of the parents and hybrids are given in the Table 1. The hybrids, in

Table 1 : Mean performance of parents and hybrids for yield, yield components and quality characters in rice

Character	Parents mean		Hybrids mean	SEd	CD
Days to 50 per cent flowering	91.58	108.36	95.64	2.46	4.83
Plant height (cm)	90.80	119.66	114.64	3.11	6.10
Ear bearing tillers per plant	9.22	7.35	7.97	0.29	0.56
Panicle length (cm)	25.04	27.77	28.74	0.89	1.74
Filled grains per panicle	162.33	216.36	221.85	9.07	17.83
Spikelet fertility (%)	84.17	84.67	76.68	2.50	4.90
1000-seed weight (g)	22.27	17.72	19.55	0.68	1.34
Grain yield (g)	17.34	16.04	19.28	1.06	2.09
Hulling (%)	79.80	78.73	79.29	0.98	1.93
Milling (%)	75.28	74.15	74.21	1.00	1.97
Head rice recovery (%)	59.34	56.24	57.60	0.96	1.88

general, were observed to be high yielding with greater panicle length and more number of filled grains per panicle, compared to the parents, as also reported by Sathya *et al.*, (1999). Maximum number of superior hybrids were observed in crosses involving APMS 6A followed by PMS 3A cyto sterile line. Among the males ITJ 226-32-1-1-1 was noticed to result in the production of maximum number of superior hybrids. Based on *per se* performance 25 hybrids had recorded significant superiority over both the checks for grain yield per plant. Among these, APMS 6A/ ITJ 210-16-1-1-1-1-1, PMS 3A/ITJ 209-20-1-1-1, PMS 3A /ITJ 226-5-1-2-3-1-1and PMS 3A / ITJ 226-32-1-1-1 hybrids had recorded significantly higher hulling, milling and head rice recovery compared to the checks.

The existence of over all heterosis was evident by the significance of parents *vs* hybrids component of variation in the analysis of variance for majority of the characters studied. The expression of heterosis in terms of number of hybrids with significant and desirable heterosis was most evident for grain yield per plant, followed by number of filled grains per panicle and panicle length as also reported by Sathya *et al.*, (1999). Heterosis for grain yield per plant was observed to range from -64.07 to 71.24 per cent over better parent; from -67.01 to 51.91 per cent over hybrid check, APHR-2 and from -64.73 to 62.41 per cent over varietal check, MTU 1010 (Table 2). High heterosis for grain yield was associated with heterosis for filled grains per panicle (Sathya *et al.*, 1999) and panicle length (Bhave *et al.*, 2002). No hybrid recorded significant and desirable heterobeltiosis for hulling, while only one hybrid (PMS 3A / ITJ 212-10-1-3-1-1) had recorded significant and desirable heterobeltiosis for milling. Viraktamath (1987) also observed no significant superiority of rice hybrids over better parent regarding hulling and milling recovery. In contrast, desirable and significant heterobeltiosis was noticed for 19 hybrids with regards to head rice recovery, similar to the findings of Gravois (1994).

Swaminathan *et al.* (1972) had reported that about 20 to 30 per cent standard heterosis is sufficient to offset the extra cost of hybrid seed. In the present investigation 23 hybrids had exhibited significant and desirable heterosis more than 20 per cent for grain yield per plant over better parent and the checks, APHR-2 and MTU-

Table 2 : Heterosis of yield, yield components and quality characters in indica tropical japonica rice hybrids

Character	Range of heterosis Over better parent	Over APHR-2	Over NTU content	Average heterobeltiosis	Number of exibiting significant and desirable heterobeltiosis
Days to 50 per cent flowering	-10.37 to 22.32	-	-	5.18	2
Plant height	-24.75 to 14.44	-	-	-3.86	11
Ear bearing tillers per plant	-46.52 to 43.96	-	-	-14.21	8
Panicle length	-15.77 to 16.86	-	-	3.59	27
Filled grains per panicle	-89.22 to 104.97	-	-	2.96	37
Spikelet fertility	-83.16 to 8.76	-	-	-10.47	8
1000-seed weight	-43.67 to 37.65	-	-	-11.61	7
Hulling	-4.48 to 1.11			-0.67	-
Milling	-7.14 to 2.74		-	-1.59	1
Head rice recovery	-41.24 to 22.09		-	-4.15	19
Grain yield per plant	-64.07 to 71.24	-67.01 to 51.91	-64.73 to 62.41	9.07	38

1010. *Per se* performance of these hybrids was also observed to be high for grain yield per plant. A perusal of the results with regards to performance of these hybrids for the quality traits revealed eight hybrids, namely APMS 6A / ITJ 210-16-1-1-1-1-1, APMS 6A / ITJ 216-19-1-2-2-1-1, PMS 3A / ITJ 209-20-1-1-1, PMS 3A/ITJ 218-19-1-1-1-1, PMS 3A / ITJ 226-32-2-1-2, PMS 3A / ITJ 226-5-1-2-3-1-1, PMS 3A / ITJ 226-32-1-1-1 and IR 68897 A / ITJ 216-5-1-2-3-1-1 showed significant and desirable heterosis for head rice recovery. Hence, these hybrids are identified as high yielding quality hybrids. Performance of these hybrids, however needs to be tested over seasons and locations, prior to commercial exploitation.

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Correlation and Path Analyses in Assam Rice Collection (*Oryza sativa* L.)

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ABSTRACT

Correlation coefficient and path analysis studies conducted with sixteen parents and their sixty four hybrids revealed that number of tillers per plant, number of productive tillers per plant and harvest index had strong positive association with yield. Besides, their inter-correlations were positive and significant, indicating the possibility of improving these characters simultaneously. The path analysis indicated that the contribution of harvest index was much through direct effects and their indirect effects by way of other traits were also much pronouncing.

Key words : Correlation, Path Analysis, Assam Rice Collection

Yield is a complex character and is associated with number of component characters which are themselves interrelated. Such inter-dependence often affects their relationship with yield, thereby making correlation coefficient ineffective. So there is a need to partition the correlations into direct and indirect effects to get the information on actual contribution of each character to yield. Thus, correlation in conjunction with path analysis could give a better insight into cause and effect relationship between different pairs of characters. This will help in the simultaneous improvement of characters along with grain yield in breeding programme. Therefore, the present study was under taken to study the association of different characters in Assam rice collection.

MATERIAL AND METHODS

Sixty four hybrids involving eight female parents *viz.*, ARC 7140, ARC11979, ARC 12194, ARC 12451, ARC 14763, ARC 15758, ARC 18023 and ARC 18214 and eight male parents *viz.*, AS 90033, ADT 41, ADT 42, ADT 43, ASD 16, IR 64, CO 47 and MDU 5 were raised in randomized block design with three replications. Normal agronomic practices were followed throughout the crop period. Ten randomly selected plants were labeled for recording observations in each replication for the characters, days to 50% flowering, plant height, number of tillers per plant, number of productive tillers per plant, flag leaf area, panicle length, grains/panicle, 100 grain weight, straw yield, harvest index and grain yield. Correlation and path coefficient analyses were carried out as suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The genotypic correlation co-efficients were higher than phenotypic correlations in general (Table 1). This indicated that low

Table 1 : Genotypic (G) and Phenotypic (P) correlations for yield and yield components in Assam rice collection

Characters		Plant height	No.of tillers/ plant	No.of Productive tillers/ plant	Flag leaf area	Panicle length	Grains/ panicle	100 grain weight	Straw yield	Harvest index	Grian yield/ plant
Days to 50%	G	-0.384**	-0.030	-0.027	-0.087	-0.100	0.232*	-0.245*	0.017	-0.167	-0.147
flowering	P	-0.331**	-0.027	-0.027	-0.057	-0.095	0.193	-0.279	0.030	-0.141	-0.117
Plant height	G		0.049	0.081	0.435**	0.404**	0.069	-0.256	0.308**	-0.112	0.111
	P		0.048	0.081	0.374**	0.387**	0.069	-0.207	0.296**	-0.100	0.103
No.of tillers /	G			0.878**	0.262*	-0.039	0.015	0.097	0.437**	0.122	0.532**
plant	P			0.834**	0.220*	-0.019	0.020	0.067	0.392**	0.115	0.464**
No.of Productive	G				0.286**	0.022	0.048	0.256	0.389**	0.171	0.539**
tillers / plant	P				0.263*	0.016	0.042	0.112	0.355**	0.147	0.465**
Flag leaf area	G					0.499**	0.133	-0.250*	0.292**	-0.093	0.143
	P					0.383**	0.124	-0.138	0.237*	-0.064	0.110
Panicle length	G						0.033	-0.259*	-0.053	-0.091	-0.127
	P						0.030	-0.177	-0.047	-0.066	-0.091
Grains / panicle	G							0.055	0.054	-0.096	-0.073
	P							0.052	0.047	-0.090	-0.069
100 grain weight	G								-0.214	0.268*	0.129
	P								-0.124	0.154	0.073
Straw yield	G									-0.530**	0.211
	P									-0.510**	0.190
Harvest index	G										0.692**
	P										0.709**

* Significant at 5% level **Significant at 1% level

phenotypic correlation might be due to the masking effect of environment in genetic association between the characters (Johnson *et al.*, 1955). The correlation of yield and yield contributing characters indicated that grain yield per plant was positive and significantly influenced by number of tillers per plant, number of productive tillers per plant and harvest index. Ashwani Panwar *et al.* (1997) and Selvarani and Rangasamy (1998) reported significant and positive correlation between number of productive tillers per plant and grain yield per plant at both levels. Number of productive tillers per plant and harvest index were significant and positively correlated with grain yield (Meenakshi *et al.*, 1999) and their interrelationship was also positive and highly significant indicating existence of linkage between the genes controlling these characters and the possibility of improving these characters simultaneously.

The meagre residual effect in path coefficient analysis indicated the importance of all yield contributing characters in deciding the yield. The direct effect of harvest index followed by straw yield was positive and high and its indirect effects through other traits were also

Table 2 : Path analysis for yield and yield components in Assam rice collection

Character	Days to 50% flowering	Plant height	No.of tillers/ plant	No.of productive tillers/plant	Flag leaf area	Panicle length	Grain/ panicle	100 grain weight	Straw yield	Harvest index	Genotypic correlation with grain yield
Days to 50% flowering	**0.0454**	-0.0024	-0.0023	0.0004	-0.0002	-0.0021	-0.0052	-0.0032	0.0130	-0.1834	-0.140
Plant height	-0.0174	**0.0064**	0.0037	-0.0012	0.0011	0.0086	-0.0015	-0.0020	0.2363	-0.1225	0.111
No.of tillers/plant	-0.0013	0.0003	**0.0764**	-0.0129	0.0006	-0.0008	-0.0003	0.0012	0.3349	0.1337	0.532**
No.of productive tillers/plant	-0.0012	0.0005	0.0670	**-0.0148**	0.0007	0.0004	-0.0010	0.0020	0.2980	0.1869	0.539**
Flag leaf area	-0.0039	0.0027	0.0199	-0.0042	**0.0026**	0.0106	-0.0030	-0.0032	0.2234	-0.1022	0.143
Panicle length	-0.0045	0.0025	-0.0029	-0.0003	0.0013	**0.0212**	-0.0007	-0.0034	-0.0406	-0.0995	-0.127
Grains/panicle	0.0105	0.0004	0.0011	-0.0007	0.0003	0.0007	**-0.0226**	0.0007	0.0413	-0.1053	-0.073
100 grain weight	-0.0111	-0.0010	0.0073	-0.0023	-0.0006	-0.0055	-0.0012	**0.0131**	-0.1638	0.2939	0.129
Straw yield	0.0007	0.0019	0.0334	-0.0057	0.0007	-0.0011	-0.0012	-0.0028	**0.7662**	-0.5814	0.211
Harvest index	-0.0076	-0.0007	0.0093	-0.0025	-0.0002	-0.0019	-0.0021	0.0035	-0.4064	**1.0962**	0.692**

Residual effect = 0.228 Diagonal bold values denote direct effects * Significant at 5 per cent level ** Significant at 1 per cent level

positive (Meenakshi *et al.*, 1999 and Murthy *et al.*, 1997). High direct effect by number of tillers per plant, panicle length and straw yield was also recorded (Sukanya, Subramanian and Rathinam 1984) and indirect effects by most of the other characters were also positive, indicating the importance of these characters for exercising selection. Eventhough, number of productive tillers per plant had high positive correlation with yield, its direct effect and indirect effects via this character on yield were negative. So, selection based on correlation alone may mislead and make it unreliable for effective selection. Therefore, an ideal rice plant should bear many number of tillers having increased panicle length to boost the yield.

Hence, improving grain yield in rice, selection should largely depend on harvest index. So, both straw yield and harvest index would also better be considered as useful indices of selection for improvement of yield.

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Combining Ability Analysis of Yield and Yield Attributes in Sesame

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ABSTRACT

Line X tester analysis using 7 ovule parents and 4 pollinators had been carried out to identify the best general and specific combiners for the breeding programme during *Kharif* 2002. Study indicated the preponderance of non additive gene action for plant height, number of primary branches, capsules on main stem, capsules on primary branches, capsules per plant, capsule length, seeds per capsule and seed yield per plant. None of the lines or testers under study exhibited significant GCA for all the traits. Lines NKD 1110, Tanuku Brown and tester Gowri exhibited significant GCA effects for most of the traits. *Per se* performance, GCA and SCA effects and heterobeltiosis suggested that the crosses NKD 1110 X Gowri and NKD1110 x Madhavi are promising for recombination breeding.

Key words : Combining Ability, Sesame

Combining ability studies provide useful information for the selection of parents for effective breeding besides elucidating the nature and magnitude of gene action involved in the inheritance of a trait. Such an information is required to design efficient breeding programme for rapid crop improvement.

MATERIAL AND METHODS

Based on D^2 analysis 7 ovule parents (Tanuku Brown, NKD 1110, K 5177, DCB 1799, SO-12-2154, EC 35-8022 and Si 320) and 4 Pollen parents (Gowri, Madhavi, Vinayak and YLM-17) were selected and crossed in line x tester mating model during *kharif* 2002. The resulting 28 hybrids and 11 parents were sown in a randomized block design with 3 replications at Agricultural Research Station, Peddapuram during *rabi* / summer 2002. Healthy crop was raised following recommended package of practices. Observations were recorded on 10 random, normal and competitive plants for 12 parameters *viz.,* plant height, days to maturity, number of primary branches, capsules on main stem, capsules on primary branches, capsules per plant, capsule length, seeds per capsule, 1000-seed weight, biological yield, harvest index and seed yield per plant and mean values were computed and line x tester analysis for combining ability was carried out as per Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of variance for combining ability is furnished in Table 1. Significance of mean sum of squares due to males and females provide a measure of the general combining ability (GCA) while the interaction of line x tester provides a measure of specific combining ability (Rojas, 1951) Significance of variance due to lines for plant height, days to maturity, 1000 seed weight and harvest index indicated that the lines differed for these traits.

Table 1 : Analysis of variance (line x tester) for 12 quantitative traits in sesame

Source of variation	d.f	Plant height	Days to maturity	No.of primary branches	Capsules on main stem	Capsules on primary branches	Capsule per plant	Capsule length	Seeds per capsule	1000 Seed weight	Biolo-gical yield	Harvest index	Seed yield per plant
Replication	1	94.77	0.12	0.46	2.80	52.57	150.61	0.0005	7.39	0.001	2.48	3.32	0.591
Treatment	38	171.23**	47.83**	1.36**	37.18**	201.75**	382.59**	0.11**	79.29**	0.71**	277.45**	67.59**	11.31**
Parents	10	136.44**	33.91	0.55**	11.53**	49.12**	81.54	0.11**	68.42**	0.041**	104.10**	39.91**	2.11
Crosses	27	186.15**	39.64**	1.70**	47.51**	248.91**	479.83	0.10**	85.57**	0.78**	350.83**	56.79**	15.10**
Parents Vs Crosses	1	116.53*	408.08**	0.45**	14.50**	454.85**	767.86**	0.11**	18.63**	5.41**	29.69**	635.83**	0.93
Lines	6	539.48*	170.54**	2.29	114.32	223.88	464.99	0.20	126.35	1.94**	369.60	165.22*	18.91
Testers	3	37.71	4.97	2.81	1.89	292.73	459.07	0.17	186.35	1.07	26.85	16.84	2.94
Line x Testers	18	93.11**	1.789**	1.32**	32.85	249.93**	488.23**	0.0647**	55.18**	0.35**	398.55**	27.31**	15.86**
Error	38	20.58	0.24	0.05	4.51	26.63	40.84	0.0002	0.75	0.001	5.43	2.28	1.20

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 2 : Variance due to general and specific combining ability effects for 12 quantitative traits in sesame

S.No.	Characters	Variance due to GCA	Variance due to SCA	σ^2A	σ^2D	Ratio $\sigma^2A : \sigma^2D$
1.	Plant height	3.10	36.26	6.20	36.26	0.17:1
2.	Days to maturity	1.26	0.77	2.52	0.77	3.27:1
3.	No.of Primary branches	0.01	0.63	0.02	0.63	0.03 :1
4.	Capsules on main stem	0.48	14.16	0.96	14.16	0.06:1
5.	Capsules on primary branches	-0.03	111.65	-0.06	111.65	-0005:1
6.	Capsules per plant	-0.28	223.69	-0.56	223.69	-0.0025:1
7.	Capsule length	0.001	0.032	0.002	0.032	0.06:1
8.	Seeds per capsule	1.01	27.21	2.02	27.21	0.07:1
9.	1000 Seed weight	0.01	0.17	0.02	0.17	0.12:1
10.	Biological yield	-1.59	196.56	-3.18	196.56	-0.016:1
11.	Harvest index	0.98	12.51	1.96	12.51	0.15:1
12.	Seed yield for plant	-0.02	7.32	-0.04	7.32	-0.005:1

Table 3 : Performance of crosses based on *per se* performance and SCA effects in sesame

		Superior performance of crosses based on *per se* performance			
S.No.	Character	Crosses	Significant SCA	Significant positive heterobeltiosis	Crosses identified for heterosis breeding
1.	Plant height	Tanuku Brown x Gowri, Tanuku Brown x Madhavi,Tanuku BrownxVinayak,Tanuku Brown x YLM 17,NKD 1110 x Gowri, NKD 1110 x Madhavi, NKD 1110 x YLM 17,K 5177 x Gowri, K 5177 x Madhavi,K 5177 x Vinayak, EC 358022 x Gowri, EC 358022 x Madhavi, EC 358022 x Vinayak, EC 358022 X YLN17, SI 320 X Gowri, SI 320 X Vinayak, SI 320 X YLM 17, SO 12-2154 x Gowri.	Tanuku Brown x YLM 17, K 5177 x Madhavi, SO 12-2154 X Gowri	Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, DCB 1799 x Madhavi	Tanuku brown x YLM 17
2.	Days to Maturity	Tanuku BrownxVinayak, NKD 1110x Gowri, NKD 1110x Madhavi, NKD1110 x Madhavi, NKD 1110x Vinayak, NKD 1110x YLM 17, DCB 1799xGowri, DCB 1799 x Vinayak, DCB 1799 YLM 17	Tanuku Brownx Vinayak, NKD 1110 x Madhavi, DCB 1799 x Gowri, SO 12-2154 x Vinayak	K 5177 x Gowri K 5177 x YLM 17	—
3.	No.of Primary Branches	Tanuku BrownxGowri, Tanuku Brown x Madhavi, Tanuku Brown x Vinyak, Tanuku Brwon x YLM 17, NKD1110x Gowri, K 5177xGowri, K 5177xVinayak, K 5177xYLM 17, DCB 1799 x Gowri, EC 358022xVinayak, EC 358022 xYLM 17, SI 320xGowri, SO12-2154xVinayak	Tanuku Brown x Vinayak, NKD 1110 x Gowri, K 5177 x YLM 17, DCB 1799 x Gowri, EC 358022 x YLM 17, SI 320 x Gowri, SO 12-2154 x Vinayak	Tanuku BrownxVinayak,Tanuku Brown x YLM 17, NKD 1110 x Gowri, DCB 1799 x YLM 17, K 5177 x Gowri, SO 12-2154 YLM 17, SI 320 x Vinayak	Tanuku Brown x Vinayak NKD 1110 x Gowri
4.	Capsules on main stem	Tanuku Brown x Vinayak,Tanuku Brown x YLM 17, NKD 1110xGowri, NKD 1110 x Madhavi, NKD 1110xVinayak, NKD 1110 xYLM 17, K 5177xVinayak, EC 358022 x Vinayak, SO 12-2154xGowri, SO12-2154 x Madhavi	Tanuku Brown x YLM 17, NKD 1110 x Madhavi, DCB 1799 x YLM 17, SI 320 x Gowri, SO 12 -2154 x Gowri	Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Madhavi, SI 320 x Gowri	Tanuku Brown x YLM 17, NKD 1110 x Madhavi
5.	Capsules on primary branches	Tanuku Brown x Gowri, Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Gowri, NKD 1110 x Madhavi, K 5177 x Vinayak, EC 358022 x YLM 17, SI 320 x Gowri, SO 12-2154 x Vinayak	Tanuku Brown x YLM 17, NKD 1110 x Madhvi, K 5177 x Vinayak,SI 320 x YLM 17,SO12 -2154x Vinayak, SI 320 x Gowri	Tanuku Brown x Vinayak, Tanuku Brown x YLM 17,NKD 1110 x Gowri, NKD1110 x Madhavi,DCB 1799 xVinayak, SO 12-2154xYLM17,EC 358022 x YLM 17, SI 320 x Vinayak, SI 320 x YLM 17	Tanuku Brown x YLM 17, NKD1110x Madhavi EC358022 x YLM 17
6.	Capsules per plant	Tanuku Brown x Gowri, Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Gowri, NKD 1110 x Madhavi, K 5177 x Vinayak, EC 358022 x YLM 17, SI 320 x Gowri, SO 12-2154 x Vinayak	Tanuku Brown x YLM 17, NKD 1110 x Madhvi, K 5177 x Vinayak, SI 320 x Gowri, EC 358022 x YLM 17, SO 12-2154 x Vinayak	Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Gowri, NKD 1110 x Madhavi, DCB 1799 x Vinayak, SO 12-2154 x YLM 17, SI 320 x Vinayak, EC 358022 x Gowri	Tanuku Brown x YLM 17, NKD1110x Madhavi

(Contd ....)

Contd........ Table 3

7.	Capsule length	Tanuku Brown x Gowri, Tanuku Brown x Vinayak, Tanuku x YLM 17, NKD 1110 x Gowri, NKD 1110 x Vinayak, K 5177 x Gowri, K 5177 x Madhavi, K 5177 x YLM17, SI 320 x Gowri, SI 320 x Madhavi, SI 320 x YLM 17, SO 12-2154 x Gowri, SO 12-2154 x Madhvi	Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Gowri, NKD 1110 x Vinayak, K 5177 x Madhavi, K 5177 x YLM 17, DCB x 1799 x YLM 17, EC 358022 x Madhavi, EC 358022 x Vinayak, SI 320 x Gowri, SO 12-2154 x Madhavi	Tanuku Brown x Gowri, Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Gowri, DCB 1799 x Madhavi, EC 358022 x Madhavi, EC 358022 x Vinayak, DCB 1799 x Gowri, EC 358022 x Gowri	Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Gowri, K 5177 x Gowri
8.	Seeds per capsule	Tanuku Brown x Gowri, Tanuku Brown x YLM 17, NKD 1110 x Gowri, K 5177 x Madhavi, DCB 1799 x YLM 17, SI 320 x Gowri, SI 320 YLM 17, SO 12-2154 x Gowri, SO 12-2154 x Madhvi	Tanuku Brown x 'YLM 17, NKD 1110 x Gowri, K 5177 x Madhavi, DCB 1799 x Vinayak, DCB 1799 x YLM 17, EC 358022 x Vinayak, EC 358022 x Madhavi, SI 320 x Vinayak, SI 320 x YLM 17, SO 12-2154 x Gowri, SO 12-2154 x Madhavi	Tanuku Brown x YLM 17, NKD 1110 xGowri, DCB 1799 x Gowri, DCB 1799 x Madhavi, K 5177 x Gowri, EC 358022 x Gowri, SI 320 x Gowri	Tanuku Brown x YLM 17, NKD 1110 x Gowri, K 5177 x Gowri
9.	1000 seed weight	Tanuku Brown x Gowri, Tanuku Brown x Madhavi, Tanuku Brown x YLM 17, NKD 1110 x Gowri, NKD 1110 x Madhavi, NKD 1110 x Vinayak, NKD 1110 x YLM 17, K 5177 x Gowri, K 5177 x Madhavi, K 5177 x YLM 17, DCB 1799 x Gowri, DCB 1799 x Madhavi, DCB 1799 x Vinayak, SO 12-2154 x Gowri, SO 12-2154 x Madhavi, SO 12-2154 x YLM 17	Tanuku Brown x YLM 17, NKD 1110 x Gowri, K 5177 x Gowri, K 5177 x Madhavi, K 5177 x YLM 17, DCB 1799 x Madhavi, DCB 1799 x Vinayak, EC 358022 x Vinayak, SI 320 x Vinayak, SI 320 x YLM 17, SO 12-2154 x Gowri, SO 12-2154 x Madhavi	NKD 1110 x Madhavi, K 5177 x Madhavi, DCB 1799 x Gowri	Tanuku Brown x Madhavi, Tanuku Brown x YLM 17, NKD 1110 x Madhavi
10.	Biological yield	Tanuku Brown x Madhavi, Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Madhavi, K 5177 x Vinayak, EC 358022 x YLM 17, SI 320 x Gowri, SI 320 x Vinayak, SI 320 x YLM 17, SO 12-2154 x Gowri	Tanuku Brown x Madhavi, Tanuku Brown x Vinayak,Tanuku Brown x YLM 17, NKD 1110 x Madhavi, K 5177 x Vinayak, K 5177 x YLM 17, DCB 1799 x Madhavi, EC 358022 x YLM 17, SI 320 x YLM 17, SO 12-2154 x Gowri	Tanuku Brown x Madhavi, Tanuku Brown x YLM 17, NKD 1110 xMahavi, DCB 1799 x YLM 17, SI 320 x Gowri	
11.	Harvest index	Tanuku Brown x Gowri, Tanuku Brown x Vinayak, NKD 1110 x Gowri, NKD 1110 x Madhavi, NKD 1110 x Vinayak, NKD 1110 x YLM 17, K 5177 x Madhavi, K 5177 x Vinayak, K 5177 x YLM 17, DCB 1799 x Madhavi, EC 358022 x Gowri, EC 358022 x Madhavi	Tanuku Brown x Vinayak, NKD 1110 x Gowri, K 5177 x YLM 17, DCB1799 x Madhavi, EC 358022 x Madhavi		
12.	Seed yeild per plant	Tanuku Brown x Gowri, Tanuku Brown x Madhavi, Tanuku Brown x Vinayak, Tanuku Brown x YLM 17, NKD 1110 x Gowri, NKD 1110 x Madhavi, YLM 17, DCB 1799 x Madhavi, EC 358022 x Gowri, EC 358022 x YLM 17, SO 12-2154 x Gowri	NKD 1110 x Gowri, NKD 1110 x Madhavi, K 5177 x Vinayak, K 5177 xYLM 17, DCB 1799 xMadhavi, EC 358022 x YLM 17, SO 12-2154 x Gowri	Tanuku Brown x Vinayak, NKD 1110 x Gowri, NKD 1110 x Madhavi, DCB 1799 x Vinayak, SI 320 x Gowri	NKD 1110 x Gowri, NKD 1110 x Madhavi

Estimates of variance due to GCA and SCA (Table 2) provide a basis for the detection of the predominant role of additive and non-additive gene effects and help to identify the parents and crosses that are responsible to bring out a particular type of gene action. Estimates of SCA variance were greater than the GCA variances for the traits, plant height and number of primary branches (Manivannan and Ganesan, 2001), capsules on main stem, capsules on primary branches and capsules per plant (Jayalakshmi *et al.*, 2000), capsule length, seeds per capsule, 1000 seed weight (Karuppaiyan and Sundaresan 2002), biological yield, harvest index and seed yield per plant (Manivannan and Ganesan, 2001) indicating the influence of non additive gene action.

Scope for successful exploitation of hybrids either for heterosis breeding or recombination breeding depends on parameters like *per se* performance, GCA effects of parents, heterosis per cent and SCA effects of crosses and the particulars are furnished in Table 3 and 4.

Based on *per se* and GCA effects of parents it can be concluded that best general combiners for plant height are Tanuku Brown and SO-12-2154 while Vinayak, NKD 1110 and K 5177 for days to maturity, Tanuku brown and Gowri for number of primary branches; Tanuku brown for capsules on primary branches and seeds per capsule, NKD 1110 for capsules on main stem and capsule length, while Tanuku Brown, NKD 1110 and Gowri were good general combiners for test weight.

Critical evaluation based on *per se* performance, SCA effects and heterobeltiosis (Table -4) indicate that the crosses NKD 1110 X Gowri and NKD 1110 X Madhavi could be promising for seed yield while, Tanuku Brown X YLM 17 for plant height, Tanuku Brown X Vinayak, NKD 1110 X Gowri for number of primary branches , Tanuku Brown X YLM 17, NKD 1110 X Madhavi for capsules on main stem and Tanuku Brown X Madhavi, Tanuku Brown X YLM 17, and NKD 1110 X Madhavi were promising for test weight.

It can be observed that a good performing parent may not be a good general combiner, a good general combiner need not always to produce a good specific combination for various traits. However, it can be noticed that at least one good general combining parent was involved in desirable specific combination and the best performing crosses involved at least one parent with high mean and crosses with significant SCA effects with atleast one parent with good GCA can be utilized for obtaining transgressive segregants for future exploitation (Paroda and Joshi 1970)

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Surya (BPT 4358), a New Rice Variety for Coastal Ecosystem Tolerant to Planthoppers and Efficient under Low Light Intensity

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ABSTRACT

BPT 4358 was identified as a potential recombinant progeny isolated from cross Sona Mahsuri x ARC 6650. The culture gave 0.95 t / ha yield advantage over the checks in station trails. The culture showed high tolerance for BPH and WBPH in the screening trials at Maruteru and Directorate of Rice Research. It has also given 200 kg ha^{-1} yield advantage over check varieties under Minikit testing in farmers' fields besides tolerance to planthoppers. It gave superior performance under low light intensity (shade conditions) in terms of grain yield, test weight, filled grains per $panicle^{-1}$ Panicles per $meter^2$, leaf area index and plant height compared to the local popular check varieties, Chaitanya and Krishna Veni. The culture had fine medium slender grain with high milling recovery.

Key Words : Planthopper Tolerent, Low Light Intensity, BPT 4358, Surya, Rice

In coastal rice ecosystem, planthoppers reduce the crop yields drastically (20% to 80%) if not effectively controlled in time. Low light intensity is another big constraint in the coastal areas especially during the *Kharif* season. The higher grain yield in Telangana and Rayalaseema when compared to coastal Andhra Pradesh are generally attributed to the less relative humidity and more sunny days especially panicle initiation onwards. Developing planthopper resistant varieties with high photosynthetic efficiency in low light is one of the best strategies for rice varietal development in this coastal rice ecosystem.

MATERIAL AND METHODS

Sona Mahsuri (BPT 3291) and ARC 6650 were utilised as parents for hybridisation with an objective to develop planthopper tolerant rice varieties. ARC 6650 obtained from Assam rice collection (ARC) is a strong donor for BPH and WBPH resistance. Pedigree method of breeding was followed. One superior derivative (recombinant) designated as BPT 4358 was selected from advanced generation breeding material and promoted to the yield trials *viz.*, Observation Yield Trial, Preliminary Yield Trial, Advance Yield Trial, at the station and Multilocation Yield Trial (MLT). Trials were conducted in randomized complete block design with three replications. It was also selected for minikit testing in the farmers fields based on its superior performance in MLT s during 1993-95.

In order to evaluate its performance under low light intensity, the culture along with other popular checks was grown under shade, maintained artificially by putting a thin kora cloth, during crop growth period and also outside, under normal conditions. The experiment was

Table 1 : Mean performance of surya (BPT 4358) in different yield trials

Year	Expt. Name	Surya, Check	Days to flowering	Plant height (cm)	EBT m^{-2} (No)	Grain yield (t ha^{-1})	Yield Advantage Actual (t ha^{-1})	% over Check
Kharif	Observation	SURYA	110	99	318	5.1	1.50	30
1986		SWARNA	116	102	294	3.6		
	Yield	CD (0.05)				0.8		
	Trail	CV%				12.5		
Kharif	Preliminary	SURYA	111	93	320	6.65	1.36	20.5
1987		VAJRAM	112	98	298	5.28		
	Yield	CD (0.05)				0.36		
	Trail	CV%				12.97		
Kharif	Advanced	SURYA	110	90	377	4.2	0.30	7.1
1988		VAJRAM	110	101	294	3.9		
	Yield	CD (0.05)				0.6		
	Trail	CV%				7.7		
Kharif	Advanced	SURYA	115	93	297	5.4	1.2	22.2
1989		VAJRAM	116	102	333	4.2		
	Yield	CD (0.05)				0.4		
	Trial	CV%				4.8		
Kharif	Multi	SURYA	113	93	347	4.6	0.40	9.0
1990	Locational	CHAITANYA	116	105	262	4.2		
	Yield	CD (0.05)				0.5		
	Trail	CV%				9.6		
	Average	SURYA	112	94.6	332	5.19	0.95	18
		Checks	114	101.2	296	4.24		

Minikit testing in farmers fields

Year conducting Minikit trial	Test entry/check	Minikit No Given	Results got	Superior to check	Mean yield BPT 4358	Check	Yield advantage Actual	Per centage
kharif 1993-95	SURYA	126	94	91	5.30	5.10	0.20	4%

IET No	Designation	Yield Performance of Surya under Initial Variety Trial (DRR) CBT	MTU	Ragolu	Mudigere	ADT	Mean
15721	BPT 4358	3.90	6.58	3.74	4.20	3.54	4.20
	Swarna (local check)	5.12	5.05	4.37	3.61	3.44	4.10
	Salivahana (common check)	5.39	4.83	4.10	3.70	2.10	4.19
	CD (0.05)	0.24	0.24	0.42	NS	0.48	
	CV (%)	3	8	5.7	36.4	8	

CBT = Coimbatore, MTU = Maruteru, ADT = Adhuthurai

Source : Annual Reports of Rice Research Unit, Bapatla 1986-1991 and 1993 to 1995

conducted in spilt plot design with 4 replications. The mean data of each trial were subjected to statistical analysis as suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

In all the yield trials, BPT 4358 exhibited superior performance for grain yield over the existing popular checks (Table 1). The superiority ranged from 0.3 in AYT-1 to 1.5 tonnes ha^{-1} in OYT.

Table 2 : Reaction of BPT 4358 against brown plant hopper at different locations

Entry Number & Designation	BPH Number Hill^{-1}			%Hopper Burn		Damage Score at					Promising at Locations
	Maruteru (MTU)	Mandya (MND)	Pondicherry (PDC)	MND	PDC	DRR (GH)	MTU	MND	PDC	Coimbatore (GH)	
***kharif* 1990**											
1. BPT 4358	17.5	12.8	14.5	0	0	5	2	3	3	5	5
2. T (N) 1	36.7	57.9	104.9	100	80	9	9	9	9	9	-
***kharif* 1991**						MND	CBT	ADT	PNR	PDC	
1. BPT 4358	-	-	-	-	-	3	5	3	4	1	5
2. T (N) 1	-	-	-	-	-	9	7	9	7	9	-

Source : Progress Reports of All India Co-ordinated Rice Improvement Project [Directorate of Rice Research (DRR)] Rajendranagar, Hyderabad 500 030, 1990 and 1991 Volume No.2 Entomology Tables 2, 3.

Table 3 : Reaction of BPT 4358 against white backed plant hopper at different locations

Entry	Designation	Damage Score at Different Locations					Promissing at locations
		DRR (GH)	CBT (GH)	Navgaon	Ludhiana (GH)	MTU 60 DT	
1	BPT 4358	6.3	5	3	4.8	3	4
2	T (N) 1	9.0	9	8	9.0	-	-

Source : Progress Reports of All India Co-ordinated Rice Improvement Project [Directorate of Rice Research (DRR)] Rajendranagar, Hyderabad 500 030, 1990 and 1991 Volume No.2 Entomology Page 2, 22.

Table 4 : Grain characters of rice variety Surya (BPT 4358)

Colour of the grain	Starw
Colour of the kernal	White
Nature of the kernal	Transculent
Abdominal white	Absent
Awning	Awnless
Length of the grain	5.82 mm
Breadth of the grain	1.48 mm
L/B-ratio	3.93
Length of the kernal	5.52 mm
Breadth of the kernal	1.43 mm
L/B-ratio	3.86
Test weight of the grain	20 g
Test weight of the kernal	14.35 g
Texture of the kernal	Transparent
Percentage of rice recovery	76%
Milling quality	Good
Endosperm nature	Non-glutinous
Cooking quality	Good, Palatable, Non-Sticky
Protien content	8.67%
Amylose content	21.73
Gel consistancy	68.68

On an average, the mean superiority was 0.95 t ha^{-1} over the checks. Simultaneously the culture BPT 4358 was screened against planthoppers and was found tolerant to BPH and WBPH at Agricultural Research Station, Maruteru, a hot spot for planthoppers and also at different locations across the country by Directorate of Rice Research, Hyderabad (Table 2 and 3).

Based on the superior performance over popular check varieties, BPT 4358 was given for minikit testing in the farmers holdings for three years and the results indicated (Table 1) that it was very much suitable for the coastal ecosystem of Guntur and Prakasam districts.

During the screening for varieties efficient under low light intensity (shaded condition), BPT 4358 has produced more panicles m^{-2} , more

Table 5 : Performance of rice under low light intensity BPT 4358

	Plant height (cm)			LAI			Panicles meter^{2}			Spikelets panicle^{-1}			Filled grains panicle^{-1} (No.)			Test weight (g)			Grian Yield (t ha^{-1})		
kharif 1992	S	N	M	S	N	M	S	N	M	S	N	M	S	N	M	S	N	M	S	N	M
BPT 4358	118	112	115	4.4	6.1	5.3	269	350	310	161	175	151	121	148	135	20.6	21.0	21.1	2.5	5.4	4.0
Chaitanya	128	121	125	4.0	5.8	4.9	262	362	312	162	187	175	113	148	131	20.3	21.0	20.7	2.1	5.5	3.8
Krishnaveni	129	124	127	3.7	6.1	4.9	209	351	280	154	181	168	107	136	122	19.1	19.3	19.2	1.9	4.3	3.1
CD Varieties		6.0			0.7			9			6			14			0.4			0.3	
Light regime	2.3			0.2			5			3			3			0.2			0.1		
Interaction			NS			0.7			20			9			16			NS			0.5
CV%		4.3			6.8						3.5			4.5			1.5			8.8	
kharif 1993																					
BPT 4358	136	128	132	4.5	6.3	5.4	279	330	305	158	176	167	123	152	138	20.2	20.6	20.4	2.6	4.9	3.7
Chaitanya	130	124	127	4.7	6.5	5.6	296	347	322	148	179	164	110	155	133	20.9	21.2	21.1	1.6	5.5	3.5
Krishnaveni	131	125	128	4.2	6.6	5.4	265	330	298	156	192	174	106	161	134	18.8	19.0	189	1.6	3.6	2.6
CD Varieties		NS			0.7			18			13			10			0.3			12	
Light regime	6			0.7			24			8			11			0.2			31		
Interaction			NS			NS			49			NS			20			NS			4.6
CV%		3.2			8.7			5.4			4.3			5.2			3.5			9.2	

S = Shaded (Low light); N = Normal; M = Mean;CD = Critical difference;CV% = Coefficient of Variation
(Source : Annual Report of Dept. of Plant Physiology, Agrl Res.Station, Maruteru for 1992 and 1993)

number of filled grains panicle^{-1} and ultimately more grain yield ha^{-1} compared to the most popular checks Chaitanya and Krishna Veni (Table 5). (Anonymous, 1992). During normal conditions, BPT 4358 was superior to Krishna Veni for grain yield, test weight, filled grains panicle $^{-1}$, panicles m^{-2} and superior to Chaitanya in plant height. This clearly indicates that BPT 4358 has higher photosynthetic efficiency even under low light intensity. State Variety Release Sub Committee released BPT 4359 under the name "SURYA" (Table 4) for commercial cultivation to the farmers on 29.11.1999. Now SURYA is being cultivated in large areas of Krishna, Guntur and East Godavari districts of coastal Andhra Pradesh.

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Character Association and Path Analyses in Roselle Hemp (*Hibiscus sabdariffa* L.)

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ABSTRACT

Roselle hemp is an important fibre yielding crop in India next to jute and the fibre is extracted from the bast region of stem. Genotypic and phenotypic correlation coefficients and path coefficient analysis were worked out based on the 51 genotypes for nine characters. Fibre yield was found to be significantly and positively correlated with plant height, number of internodes per plant, basal stem diameter, bark thickness and fibre length. The above yield components also exhibited significant positive inter correlations among themselves. Path coefficinet analysis indicated that plant height, number of internodes per plant, bark thickness and fibre length had maximum positive direct effect on fibre yield per plant. The characters plant height bark thickness energed as most potent characters influencing fibre yield per plant in the selection programme of roselle hemp.

Key words : Correlation, Path Analysis, Roselle Hemp

An effective breeding programme for development of good quality and high yielding varieties requires preliminary information on the nature and magnitude of genetic variation in the available material and association of characters with fibre yield and among themselves. The path coefficient analysis provides an effective means of finding direct and indirect causes of association of yield components on fibre which will help in the simultaneous improvement of many characters in direct crop evolution.

MATERIAL AND METHODS

The study was conducted at Agricultural College Farm, Bapatla during *Kharif* 2004. The experiment was laid out in a randomized block design with four replications. The recommended package of practices was followed to raise a good crop. Data were recorded on ten randomly selected plants from each treatment for the characters, days to 50% flowering, plant height (cm), number of internodes per plant, internodal length(cm), basal stem diameter (cm), bark thickness(cm), fibre wood ratio, fibre length (cm) and fibre yield per plant (g). Genotypic, phenotypic and environmental correlation coefficients were calculated as suggested by Johnson *et al.* (1955). The genotypic correlation coefficients were used to find out the direct and indirect effects of the component characters on fibre yield per plant, according to Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences for all the characters, there

Table 1 : Phenotypic and genotypic correlation coefficients in 51 roselle hemp (*Hibiscus sabdariffa* L.) genotypes

Character		Plant height	Number of internodes per plant	Internodal length	Basal stem diameter	Bark thickness	Fibre wood ratio	Fibre length	Fibre yield/ plant
1 Days to 50% flowering	P	-0.0149	-0.0946	0.1401*	-0.0736	-0.1247	0.0046	-0.0171	0.0232
	G	(-0.0154)	(-0.0971)	(0.1451)*	(-0.0755)	(-0.1305)	(0.0060)	(-0.0300)	(0.0235)
2 Plant height	P		0.9480**	-0.8730	0.8336**	0.8420**	-0.3388**	0.9575**	0.8185)**
	G		(0.9746)**	(-0.8752)**	(0.8372)**	(0.8459)**	(-0.3405)**	(1.0133)**	(0.8196)**
3 Number of internodes per plant	P			-0.9446**	0.8339**	0.7931**	-0.3364**	0.9139**	0.7772)**
	G			(-0.9702)**	(0.8593)**	(0.8165)**	(-0.3485)**	(0.9900)**	(0.7976)**
4 Inter nodel length	P				-0.7553**	-0.7122**	0.3945**	-0.8447**	-0.7011**
	G				(-0.7584)**	(-0.7159)**	(0.3966)**	(-0.8927)**	(-0.7024)**
5 Basal stem diameter	P					0.9708**	-0.2730**	0.8479**	0.6866**
	G					(0.9768)**	(-0.2749)**	(0.8947)**	(0.6888)**
6 Brak thickness	P						-0.2802**	0.8129**	0.6655**
	G						(-0.2812)**	(0.8558)**	(0.6679)**
7 Fibre wood ratio	P							-0.3271**	-0.2405**
	G							(-0.3437)**	(-0.2412)**
8 Fibre length	P								0.7912**
	G								(0.8331)**

P = Phenotypic correlation coefficient
G= Genotypic correlation coefficient

* Significant at 5% level
** Significant at 1% level

by suggesting the presence of variability among the genotypes assessed. The phenotypic and genotypic correlation coefficients for different pairs of characters are given in Table 1. In general, the genotypic correlations were higher in magnitude than the phenotypic ones, which gives an idea that there is inherent association between various characters in agreement with Johnson *et al.* (1955). This may confirm the considerable role of environment in modifying the expression of the genotypes (Sita Devi *et al.*, 1990). Positive and significant association of plant height, number of internodes per plant, basal stem diameter, bark thickness and fibre length with fibre yield suggested that effective improvement in roselle hemp through these components could be achieved by simple selection. Similar results were also reported by Anuradha and Surya Kumari (2002), Palve *et al.* (2003) and Roy and Ghosh Dastidar (2004).

Yield is a very complex quantitative character and was greatly influenced by its various components, directly as well as indirectly via other characters. For an effective recommendation of selection indices, these effects and their interrelationship must need path analysis. Out of nine fibre yield components, the plant height and bark thicknesss had maximum direct effect (0.8630, 1.3762, 0.2906 and 0.4374) in positive direction (Table 2). The direct effect

Table 2 : Path coefficients of yield components in 51 genotypes of roselle hemp (*Hibiscus sabdariffa* L.)

Character		Days to 50% flowering	Plant height	Number of internodes per plant	Internodal length	Basal stem diameter	Bark thick-ness	Fibre wood ratio	Fibre length	Correlation with fibre yield/plant
1 Days to 50% flowering	P	**0.0400**	-0.0006	-0.0038	0.0056	-0.0029	-0.0050	0.0002	-0.0007	0.0232
	G	**0.0369**	-0.0006	-0.0036	0.0054	-0.0028	-0.0048	0.0002	-0.0011	0.0235
2 Plant height	P	-0.0129	**0.8630**	0.8181	-0.7534	0.7626	0.7267	-0.2924	0.8263	0.8185
	G	-0.0211	**1.3762**	1.3412	-1.2045	1.2209	1.1642	-0.4686	1,3946	0.8196
3 Number of inter-nodes per plant	P	-0.0153	0.1531	**0.1615**	-0.1525	0.1346	0.1281	-0.0543	0.1476	0.7772
	G	0.0551	-0.5529	**-0.5673**	0.5504	-0.4875	-0.4632	0.1977	-0.5616	0.7976
4 Inter nodel length	P	0.0143	-0.0890	-0.0963	**0.1020**	-0.0770	-0.0726	0.0402	-0.0862	-0.7011
	G	-0.0394	0.2375	0.2633	**-0.2714**	0.2058	0.1943	-0.1076	0.2423	-0.7024
5 Basal stem diameter	P	0.0344	-0.4130	-0.3898	0.3531	**-0.4675**	-0.4538	0.1276	-0.3963	0.6866
	G	0.0480	-0.5640	-0.5463	0.4821	**-0.6357**	-0.6210	0.1748	-0.5688	0.6888
6 Bark thickness	P	-0.0363	0.2447	0.2305	-0.2070	0.2822	**0.2906**	-0.0814	0.2363	0.6655
	G	-0.0571	0.3700	0.3571	-0.3131	0.4273	**0.4374**	-0.1230	0.3743	0.6679
7 Fibre-wood Ratio	P	0.0002	-0.0154	-0.0153	0.0179	-0.0124	-0.0127	**0.0454**	-0.0149	-0.2405
	G	0.0005	-0.0267	-0.0274	0.0311	-0.0216	-0.0221	**0.0785**	-0.0270	-0.2412
8 Fibre-length	P	-0.0014	0.0757	0.0723	-0.0668	0.0670	0.0643	-0.0259	**0.0791**	0.7912
	G	0.0006	-0.0200	-0.0195	0.0176	-0.0176	-0.0169	0.0068	**-0.0197**	0.8331

P = Phenotypic path coefficientValues in bold are direct effects.
G= Genotypic path coefficientResidual effect for phenotypic path and genotypic path 0.561, 0.651, respectively

of the remaining characters was quite low.The strong positive association of plant height with fibre yield was due to its direct contribution which was also the highest in magnitude, thereby indicating a true correlation and could be taken as a major component for the improvement of fibre yield. The indirect effect of plant height via all other characters studied was positive except for days to 50% flowering, internodal length and fibre wood ratio. The direct effect was maximum in negative direction for the character, basal stem diameter(-0.4675, -0.6357) and its direct effects were positive for days to 50% flowering, internodal length, fibre wood ratio and fibre yield per plant, in agreement with Appalaswamy *et al.* (1995), Kameswara Rao(1996) and Anuradha and Suriya Kumari (2002).

Plant height, number of internodes per plant, bark thickness and fibre length should be considered essential while selecting for high fibre yield because they have high genotypic value and maximum direct and indirect effect towards fibre yield. The residual effect was low indicating that characters other than studied have very little effect on fibre yield.

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Genetic Divergence in Aromatic Rice Genotypes

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ABSTRACT

Genetic divergence was studied for yield and quality traits in 19 aromatic rice genotypes. These aromatic rice genotypes include high yielding Basmati and other aromatic short grain genotypes. Based on the genetic distance, 19 genotypes were grouped into 5 clusters. The distribution of genotypes into various clusters was at random indicating that geographical diversity and genetic diversity were not related. The characters like water uptake, days to 50% flowering contributed maximum towards genetic divergence.

Key words : *Oryza sativa*, Genetic Divergence, Aromatic Rice

Genetic improvement mainly depends on the amount of genetic variability present in the population. Information on the nature and degree of divergence would help the plant breeder in choosing the right type of parents for breeding programme. Hence, estimation of genetic diversity for grain yield and quality parameters among genotypes is important for planning the future breeding programme. Traditional aromatic rice genotypes are low yielders but having superior grain quality characters. In the present study attempt was made to classify and understand nature and magnitude of diversity by using Mahalanobis' D^2 statistics.

MATERIAL AND METHODS

The material for this study consisted of 19 aromatic rice genotypes collected from different states.. The material was grown in randomized block design with three replications during *Kharif* 2004-05. Thirty days old seedlings were transplanted with inter-row spacing of 30 cm and intra-row spacing of 15 cm.

Recommended package of practices and need based plant protection measures were followed. Observations were recorded on days to 50 per cent flowering, plant height, productive tillers per plant, panicle length, grains per panicle, 1000-grain weight, grain yield per plant, hulling percentage, milling percentage, head rice recovery percentage, kernel L/B ratio, kernel length after cooking, elongation ratio, volume expansion ratio, water uptake, amylose content, alkali spreading value and gel consistency.

Two hundred gram paddy of each genotype was taken and shelled in a Satake Dehusker (type THU 35A) and milled in Satake grain testing mill (Type-TM 05) under standard condition to obtain uniformly 5-6 per cent polish. Milled samples were sieved to separate whole kernels from the broken ones. Full rice and three-fourth kernels were taken as whole milled rice for computation of kernel length and kernel breadth and were measured with Satake grain shape tester as indicated by Murthy and Govinda Swamy (1967). L/B ratio was calculated as the

Table 1 : Clustering pattern among different aromatic rice genotypes

Cluster	No. Genotypes	Genotypes included
I	12	Amritbhog, Atmashital, Tilakchandan, Badshabhog, RAU-3030, Krishna kamod, Chittimutyalu, Vasumati, Pusa Basmati 1, Basmati 370, Plant Dhan 16, Mugad Sugandha
II	3	Yamini, Basmati 386, Taroari Basmati
III	2	RAU 3043, Kalanamak
IV	1	Ranbir Basmati
V	1	Kasturi

Table 2 : Intra and inter cluster average of D^2 values of different aromatic rice genotypes

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Cluster I	2486.66	4576.91	5448.18	4532.81	4965.61
Cluster II		2612.88	8984.91	5991.23	7956.64
Cluster III			1340.15	11332.08	6536.37
Cluster IV				0.00	3729.97
Cluster V					0.00

Underlined values indicate intra-cluster D^2 values and other values indicate inter-cluster D^2 values

ratio of mean kernel to mean kernel breadth. Kernel length after cooking was determined by following the procedure described by Vergheese (1950). Elongation ratio was calculated as the ratio of mean cooked kernel length to mean uncooked kernel length. Alkali spreading value, an indirect measure of gelatinization temperature was estimated as per Little *et al.* (1958). Estimation of amylose as per Juliano (1991). Water uptake was recorded by following the procedure described by Beachell and Stansel (1963).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the characters indicating existence of variability among the genotypes for the characters studied. Based on the relative magnitude of D^2 values 19 genotypes were grouped in to 5 clusters (Table 1). The cluster I was the biggest cluster consisting of 12 genotypes followed by 3 in cluster II, 2 in cluster III, I in cluster IV and V.

The clustering pattern of genotypes revealed that the genotypes originated from different states were clubbed together or genotypes originated from same state were distributed in different clusters. As observed from the clusters, the genotypes included in cluster I are originated from Andhra Pradesh, Chattisgarh, Uttar Pradesh which indicates that there was no parallelism between clustering pattern and geographical distribution of genotypes (Nayak *et al.* (2004), Vanaja *et al.* (2003) and Manonmani

Table 3 : Cluster means for yield and quality characters in different rice genotypes (cluster analysis)

	Days to flowering	Plant height	NBT	Panicle length	NGP	1000 gr wt	Grain yield	Hulling (%)
Group I	83.67	134.21	10.49	27.92	122.06	15.21	9.91	77.64
Group II	85.33	103.03	12.80	25.00	80.22	23.16	8.73	75.17
Group III	122.33	142.50	11.70	28.50	164.67	11.34	9.26	78.93
Group IV	77.67	113.89	10.87	25.53	74.00	20.71	5.81	73.37
Group V	95.67	110.38	9.50	30.67	123.67	23.83	12.44	78.70
	Milling (%)	HRR (%)	L/B ratio	KLAC	ER	VER	WU	AC
Group I	68.96	62.39	0.85	11.06	1.98	4.49	173.94	22.28
Group II	66.87	47.07	4.51	14.74	1.96	4.32	207.00	22.28
Group III	69.62	60.77	2.25	10.20	2.32	4.54	193.17	22.99
Group IV	64.37	56.33	3.87	11.27	1.61	5.42	295.67	17.60
Group V	66.03	29.47	2.69	9.27	1.50	4.38	166.67	24.50

and Fazlullah Khan (2003). Hence, it was concluded that there was no relationship between geographical distribution and genetic diversities.

The maximum intra cluster distance was observed in cluster II (2612.88) followed by cluster I (2486.66) and the maximum intra cluster distance 0.000 (cluster IV and cluster V). The maximum inter cluster distance was observed between cluster III and IV (11332.08), followed by cluster II and III (8984.91). The selection of divergent genotypes from above clusters would produce a broad spectrum of variability for yield and quality traits, which may enable further selection and genetic improvement. The hybrids developed from the selected genotypes with in the limits of compatibility of these clusters may produce high magnitude of heterosis or desirable transgressive segregants that could be desirable in rice breeding programme. Water uptake and days to 50% flowering contributed maximum towards genetic divergence.

The average cluster wise mean values for different characters are presented in Table 3. The genotypes included in cluster III, RAU-3043 and Kalanamak showed maximum values for the characters like days to 50% flowering, plant height, number of grains per panicle, hulling percentage, milling percentage and elongation ratio. The genotypes like Yamini, Basmati 386 and Taroari Basmati in cluster II exhibited high cluster mean values for important grain quality characters like L/B ratio, KLAC and yield characters like number of productive tillers per plant. The genotype Kasturi included in cluster V showed high cluster mean values for water uptake, alkali spreading value, gel consistency, panicle length, 1000 grain weight and grain yield per plant.

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Multivariate Analysis in Maghi Sorghum [*Sorghum bicolor* (L.) Moench]

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ABSTRACT

Eighty genotypes of sorghum were evaluated for genetic diversity using Mahalanobis' D^2 statistic and principal component analysis. The pattern of distribution of 80 genotypes obtained from different agro-ecological regions was 12 clusters incase of D^2 analysis and 9 clusters incase of principal component analysis. Ear head weight contributed maximum towards genetic divergence followed by days to 50% flowering and dry fodder yield per plant. The best clusters with regard to grain yield and dry fodder yield were cluster VIII and VII in case of D^2 analysis where as cluster II and I in principal component analysis. The principal component analysis identified three principal components which explained 74.32% variability in sorghum. The principal component analysis enabled loading of similar type of variables on a common principal component. Genotypes, EP-113, EP-16, EP-19, EP-22 (based on PC1 axis), SEVS-22, SEVS-18, EP-40 (based on PC II axis), IS-15448 and E-51 (based on PC III axis) were found better performers.

Key Words : Maghi Sorghum, D^2 Analysis, Principal Component Analysis

In any crop improvement programme, genetic diversity is an essential prerequisite for hybridization. Inclusion of diverse parents in hybridization helps in isolation of superior recombinants. Several methods for multivariate analysis such as D^2 analysis, cluster analysis, principal component analysis and metroglyph analysis have been shown to be useful in selecting genetically distant parents for hybridization. Thus, in present investigation, attempt has been made to identify the extent of genetic diversity among the 80 genotypes of sorghum under Maghi (late August to early September) situation using D^2 analysis and principal component analysis.

MATERIAL AND METHODS

Eighty diverse sorghum genotypes (Table 1) were raised in randomized block design with two replications during Maghi (late August to early September), 2004 at Agricultural Research Station, Madhira. Each genotype was raised in two rows of 4m length adopting a spacing of 45x15 cm. The biometrical observations were recorded for ten traits on five randomly selected plants per genotype per replication. D^2 analysis (Mahalanobis, 1928), principal component analysis (Jackson, 1991) and hierarchial cluster analysis (Anderberg, 1993) were carried out using SPSS computer programme.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant difference among the genotypes for ten characters. This difference indicated the existence of significant amount of variability among the genotypes for the characters studied. The 80 genotypes were grouped into 12 clusters in case of D^2 analysis (Table 2) whereas 9 in Ward's method (Table 3 and Fig. 1). The variation in the composition of individual cluster with regard to the number of genotypes indicated the

Table 1 : List of the genotypes of sorghum [*Sorghum bicolor* (L.) Moench] under study

S.No.	Genotype	S.No.	Genotype
1	EP-1	41	EP-104
2	EP-2	42	EP-105
3	EP-3	43	EP-106
4	EP-4	44	EP-107
5	EP-5	45	EP-108
6	EP-6	46	EP-111
7	EP-7	47	EP-112
8	EP-8	48	EP-113
9	EP-11	49	EP-114
10	EP-12	50	EP-115
11	EP-13	51	EP-116
12	EP-15	52	EP-118
13	EP-16	53	SEVS-1
14	EP-18	54	SEVS-2
15	EP-19	55	SEVS-3
16	EP-21	56	SEVS-5
17	EP-22	57	SEVS-6
18	EP-24	58	SEVS-9
19	EP-25	59	SEVS-11
20	EP-26	60	SEVS-12
21	EP-28	61	SEVS-16
22	EP-30	62	SEVS-18
23	EP-32	63	SEVS-20
24	EP-33	64	SEVS-22
25	EP-34	65	SEVS-27
26	EP-35	66	GGUB-47
27	EP-37	67	GGUB-49
28	EP-39	68	POP-9
29	EP-40	69	POP-31
30	EP-41	70	IS-13657
31	EP-45	71	IS-15448
32	EP-46	72	IS-15455
33	EP-49	73	IS-25011
34	EP-50	74	IS-25015
35	EP-51	75	E-41
36	EP-52	76	E-51
37	EP-97	77	E-54
38	EP-98	78	NSS-7856
39	EP-100	79	NSS-7864
40	EP-102	80	APP-4

presence of large amount of diversity in the population. On the basis of D^2 analysis and PCA, the scattering of genotypes from the same geographic region to different clusters might be due to the heterogeneity, genetic architecture of the populations, past history of selection, development traits and degree of general combining ability (Murthy and Arunachalam, 1966).

The results have clearly indicated that there is no parallelism between the geographic diversity and genetic diversity in sorghum. This is in accordance with the findings of Gurpreet Singh (2001) and Umakanth *et al.* (2003). On the basis of D^2 analysis the maximum intra-cluster distance (D value) was observed in cluster III (26.2) and it was zero for cluster IV, V, VI, VII, VIII, IX, X, XI and XII while on the basis of principal component analysis the maximum intra-cluster distance was observed in cluster V (11.97) and the minimum in cluster VIII (3.59).

Similarly, the maximum inter-cluster distance was observed between X and XII (78.4) while the least between IV and VI (16.7) on the basis of D^2 analysis. It was the highest between clusters II and IX (169.87) and minimum between II and IV (10.60) on the basis of principal component analysis (Table 4 and 5). The hybridization between genotypes from the medium inter-cluster distances should give rise to heterotic hybrids in subsequent segregating generations.

The additional advantage of D^2 analysis is the contribution of various characters (Table 6) towards the expression of the genetic divergence. This analysis indicated that the ear head weight (47.85%), days to 50% flowering (18.99) and dry fodder yield per plant (16.23)

Fig 1 : Diagram illustrating the clustering pattern of genotypes of sorghum [*Sorghum bicolor* (L.) Moench] by Ward's method (Using PCA scores)

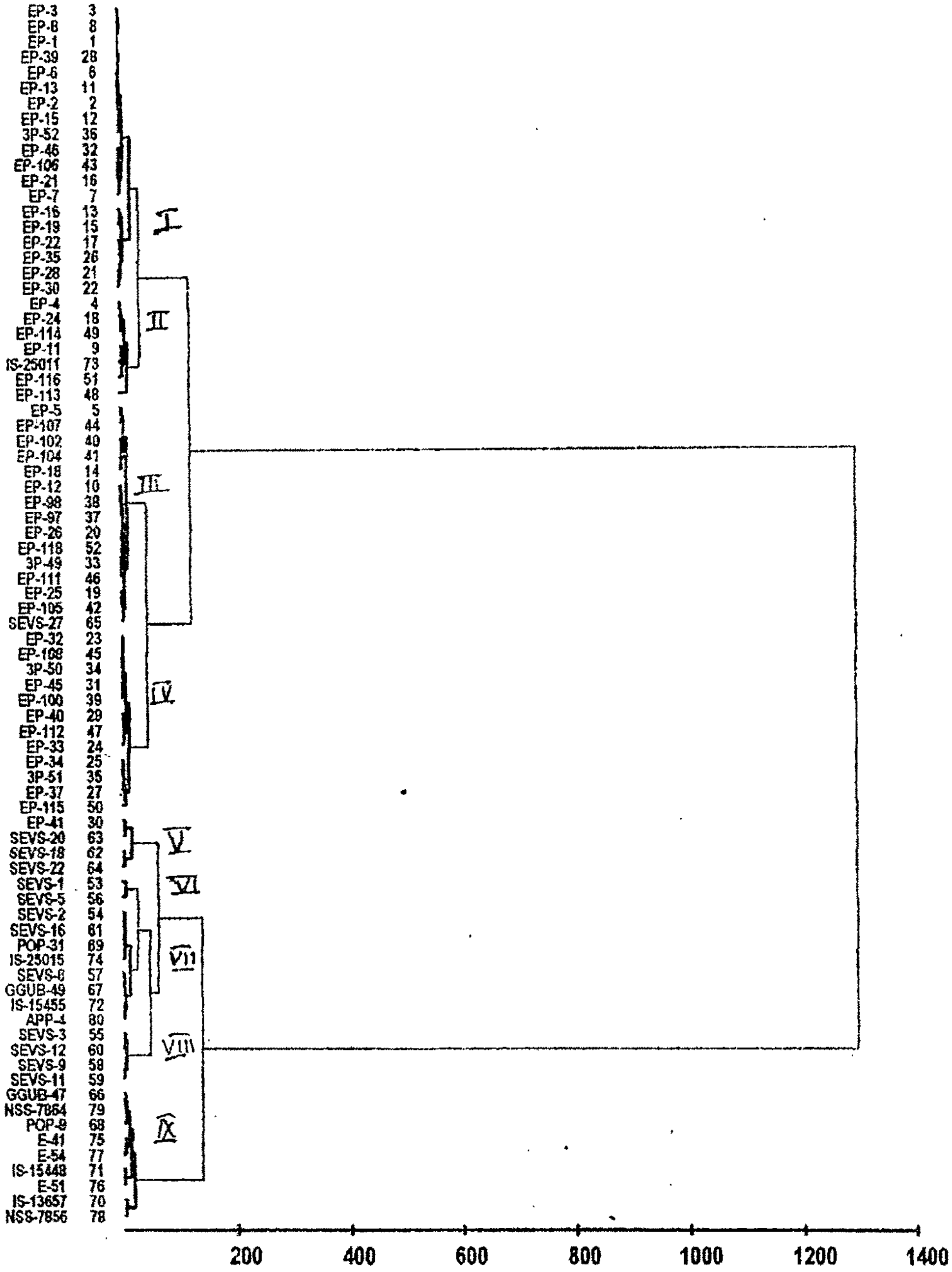

Table 2 : Distribution of 80 genotypes of sorghum [*Sorghum bicolor* (L.) Moench] in different clusters based on D^2 analysis

S.No.	Cluster No.	Genotypes	Number of genotypes
1	I	EP-4, EP-15, EP-46, EP-118, EP-2, EP-6, EP-39, EP-3, EP-106, EP-7, EP-24, EP-26, EP-50, EP-21, 13, EP-1, EP-52, EP-32, EP-98, EP-18, EP-102, EP-107, EP-104, EP-108, EP-45, EP-111, EP-30, EP-37, EP-8, SEVS-11, EP-5, EP-25, EP-26, EP-97, EP-51	35
2	II	EP-41, EP-105, SEVS-27, EP-49, EP-12, EP-34, EP-100, EP-35, EP-112, EP-115, EP-33, EP-22, SEVS-22, EP-40,	14
3	III	SEVS-3, SVES-12, IS-25015, SEVS-16, SEVS-2, SEVS-5 GGUB-49, E-41, NSS-7864, GGUB-47, POP-9, E-51, E-54, IS-15448, POP-31, IS-15445, SEVS-6, APP-4, SEVS-1, NSS-7856, IS-13657, SEVS-18	22
4	IV	EP-11	1
5	V	IS-25011	1
6	VI	EP-16	1
7	VII	EP-19	1
8	VIII	EP-113	1
9	IX	EP-114	1
10	X	EP-116	1
11	XI	SEVS-9	1
12	XII	SEVS-20	1

contributed towards more than 80 per cent of total divergence in the material. The additional advantage in hierachial cluster analysis (based on PCA scores) is identifying sub-cluster of the major groups at different levels so that each small group can be critically analysed.

In the present investigation, principal component (PC) method was used to extract the principal factor (PF) as it does not require the assumption of normal distribution of population. The PC's with eigen values >1 were retained and <1 were considered non significant (Legendre and Legendre, 1984). The first PC's showed eigen values more than one and they together explained 74.32% of variability (Table 7). The first PC explained 45.47% of the total variability in the set of all varieties and remaining ones accounted for progressively lesser and lesser amount of variation.

Principal factor scores (PF scores) for all the 80 genotypes were estimated in all the 3 PC's and utilized to construct precise 2D plot and 3D plot (Fig 2&3). All the genotypes (names and numbers assigned are given in Table 1) were plotted for PC_1, PC_2 and PC_3 which cumulatively explained 74.32% variability and accounted for all the characters (Fig 2). This plot clearly indicated the genotypes EP-113 (48), EP-16 (13), EP-19 (15) and EP-22 (17) clustering towards positive side of PC axis.

The genotypes SEVS-22 (64), SEVS-18 (62) and EP-40 (29), stood towards positive portion of PC_2 axis while, genotypes IS-15448 (71) and E-51 (76) found place towards better end when PC_1, PC_2, PC_3 were consisted simultaneously and are supposed to be superior for these 3 factors and hence superior for all the characters which 3 of these factors represented.

Fig 2 : Two dimesional graph showing relative position of genotypes of sorghum [*Sorghum bicolor* (L.) Moench] based on PCA scores

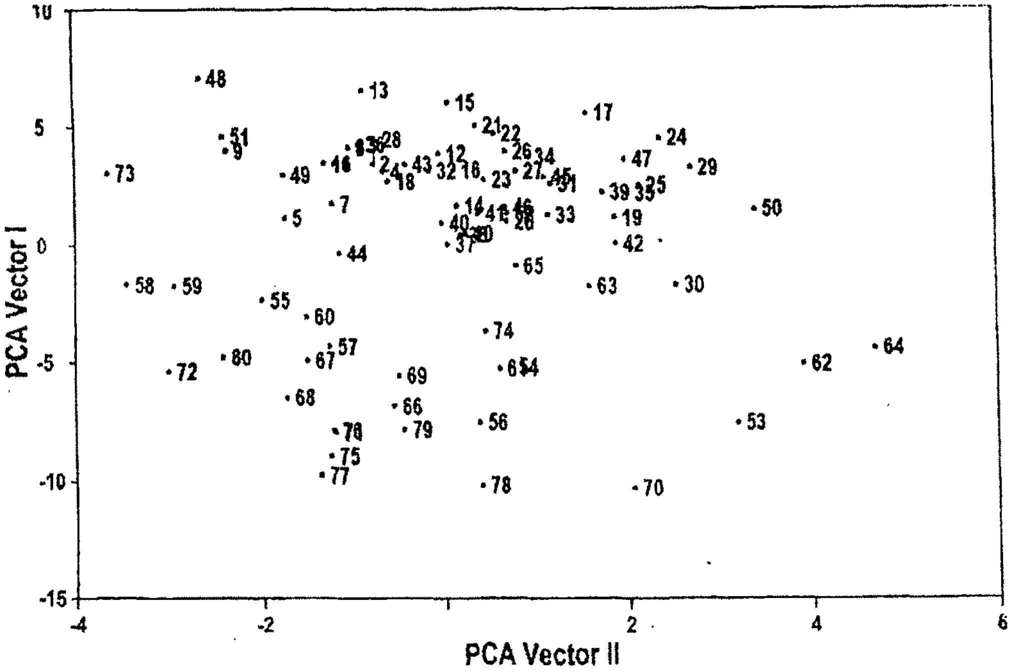

Table 3 : Distribution of 80 genotypes of sorghum [*Sorghum bicolor* (L.) Moench] in different clusters using Ward's method

S.No.	Cluster No.	Genotypes	Number of genotypes
1	I	EP-3, EP-8, EP-1, EP-39, EP-6, EP-13, EP-2, EP-15, EP-52, EP-48, EP-101, EP-21, EP-7, EP-16, EP-19, EP-22, EP-35, EP-28, EP-30	19
2	II	EP-4, EP-24, EP-114, EP-11, IS-25011, EP-116, EP-113	7
3	III	EP-5, EP-107, EP-102, EP-104, EP-18, EP-12, EP-98, EP-97, EP-26, EP-118, EP-49, EP-111, EP-25, EP-105, SEVS-27	15
4	IV	EP-32, EP-108, EP-50, EP-45, EP-100, EP-40, EP-112, EP-33, EP-34, EP-51, EP-37, EP-115	12
5	V	EP-41, SEVS-20, SEVS-22, SEVS-18	4
6	VI	SEVS-1, SEVS-5	2
7	VII	SEVS-2, SEVS-16, POP-31, IS-25015, SEVS-6, GGUB-49, IS-15455, APP-4	8
8	VIII	SEVS-3, SEVES-12, SEVES-9, SEVES-11	4
9	IX	GGUB-47, NSS-7864, POP-9, E-41, E-54, IS-15448, E-51, IS-13657, NSS-7856	9

Table 4 : Average intra-and inter-cluster divergence (D²) values of 12 clusters for 80 genotypes of sorghum [*Sorghum bicolor* (L.) Moench]

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX	Cluster X	Cluster XI	Cluster XII
Cluster I	**382.71** **(19.5)**	948.25 (30.7)	1641.69 (40.5)	794.47 (28.1)	679.65 (26.0)	923.94 (30.3)	668.74 (25.2)	732.05 (27.0)	1444.19 (38.0)	1658.58 (40.7)	2147.63 (46.3)	1982.50 (44.5)
Cluster II		**525.17** **(22.9)**	1942.51 (44.0)	2447.18 (49.4)	2107.78 (45.9)	2398.45 (48.9)	919.60 (30.3)	1776.32 (42.1)	3449.18 (58.7)	3854.67 (62.0)	4503.42 (67.1)	936.46 (30.6)
Cluster III			**688.81** **(26.2)**	2444.75 (49.4)	2414.09 (49.1)	3393.86 (58.2)	2547.78 (50.4)	3225.15 (56.7)	3371.33 (58.0)	3906.63 (62.5)	2908.43 (53.9)	2050.32 (45.2)
Cluster IV				0.00 (0.00)	304.14 (17.4)	279.81 (16.7)	1289.71 (35.9)	531.92 (23.0)	431.89 (20.7)	370.02 (19.2)	789.11 (28.0)	4340.30 (65.8)
Cluster V					**0.00** **(0.00)**	574.93 (23.9)	1422.63 (37.7)	512.75 (22.6)	409.75 (20.2)	535.10 (23.1)	995.60 (31.5)	3517.87 (59.3)
Cluster VI						**0.00** **(0.00)**	895.81 (29.9)	290.20 (17.0)	722.33 (26.8)	577.70 (24.0)	1671.92 (40.8)	4393.46 (66.2)
Cluster VII							**0.00** **(0.00)**	607.20 (24.6)	2554.09 (50.5)	2289.13 (47.8)	3733.50 (61.1)	2130.40 (46.1)
Cluster VIII								**0.00** **(0.00)**	1200.14 (34.6)	891.11 (29.8)	2371.48 (48.6)	3681.05 (60.6)
Cluster IX									**0.00** **(0.00)**	444.46 (21.0)	450.7 (21.2)	5313.57 (72.8)
Cluster X										**0.00** **(0.00)**	950.47 (30.8)	6150.95 (78.4)
Cluster XI											**0.00** **(0.00)**	6145.09 (78.3)
Cluster XII												**0.00** **(0.00)**

Figures in parentheses are 'D' values Figures in bold indicates intra-cluster D² and D values

Table 5 : Intra-cluster (bold) inter-cluster Euclidean² distance values for 80 genotypes of sorghum [*Sorghum bicolor* (L.) Moench]

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX
Cluster I	**4.61**	12.36	17.69	11.07	74.14	154.39	89.67	49.17	166.26
Cluster II		**8.49**	21.80	21.90	87.14	152.36	84.59	43.31	169.87
Cluster III			**4.12**	10.60	30.13	77.88	38.00	20.26	95.98
Cluster IV				**4.62**	46.26	117.85	72.86	47.28	143.86
Cluster V					**11.97**	31.91	26.95	38.90	53.01
Cluster VI						8.31	19.68	54.02	26.12
Cluster VII							**5.17**	14.14	25.90
Cluster VIII								**3.59**	51.58
Cluster IX									**10.98**

Fig 3 : Three dimesional graph showing relative position of genotypes of sorghum [*Sorghum bicolor* (L.) Moench] based on PCA scores

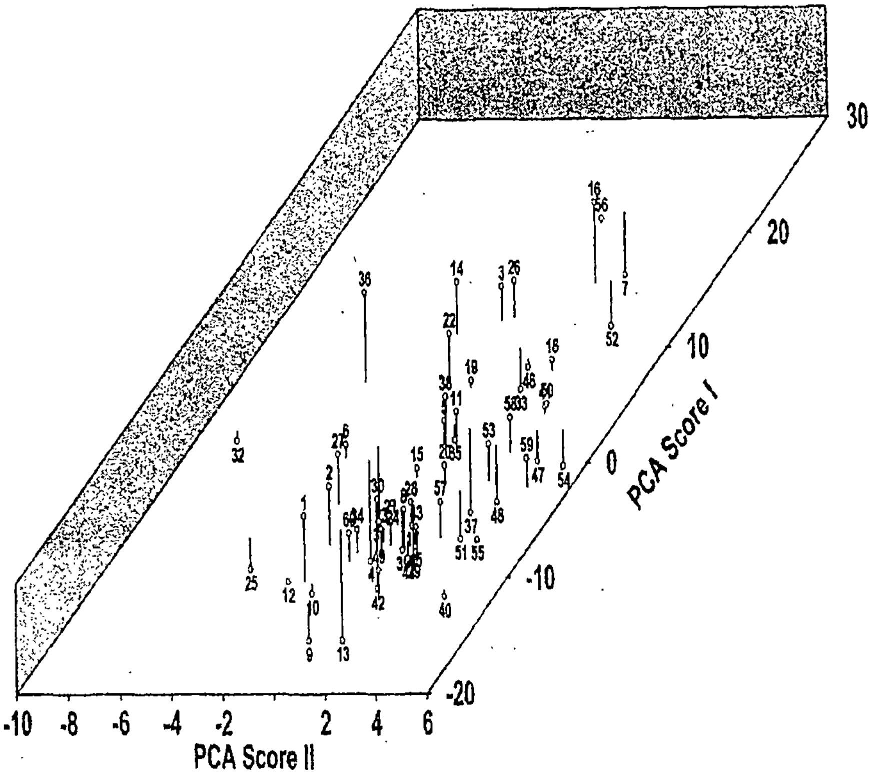

Table 6 : Contribution of different characters towards genetic divergence among 80 genotypes of sorghum

S.No.	Character	Per cent contribution towards divergence	Rank
1	Days to 50% flowering	18.99	2
2	Days to maturity	10.38	4
3	Plant height (cm)	0.44	7
4	Ear head length (cm)	1.30	6
5	Ear head weight (g)	47.85	1
6	100 grain weight (g)	0.09	9
7	Harvest index (%)	0.06	10
8	Leaf area index	4.27	5
9	Dry fodder yield / plant (g)	16.23	3
10	Grain yield / plant (g)	0.38	8

Table 7 : The eigen values, per cent variability, cumulative per cent variability for four principal components in sorghum [*Sorghum bicolor* (L.) Moench]

	Principal component 1	Principal component 2	Principal component 3	Principal component 4
Eigen value	4.54	1.69	1.19	0.77
% of variation observed	45.47	16.92	11.97	7.72
Cumulative total % variation	45.47	62.40	74.32	82.11

The plot of PC_1, PC_2 and PC_3 accounting for about 74.32% variation showed clear differentiation of genotypes according to their cluster member ship for each cluster. Genotypes belonging to a common cluster have fallen nearer to each other and vice-versa there by confirming the results of cluster analysis. The genotypes EP-113, EP19, and E-51 found superior in PCA were also found the members of the clusters *i.e.,* Cluster II and IX.

Both D^2 analysis and PCA revealed a single concept of non-correspondence of genetic divergence and geographic diversity. In broad sense both the methods of classifying genotypes into different groups is equally useful but PCA gave an additional advantage of identifying sub-clusters of the major groups at different levels so that each small group can be critically analysed.

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Combining Ability Studies in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

Forty hybrids were synthesized using line x tester mating design involving four cytoplasmic male sterile lines and ten genotypes in sunflower. The estimates of variance components revealed that *sca* variance was higher in magnitude compared to *gca* variance for all the characters studied, indicating the preponderance of non-additive gene action. The line DCMS 18 and tester DRS 5 were found to be superior general combiners for majority of the yield attributes. The crosses DCMS 5 x DRS 16, DCMS 5 x RHA 6D-1, DCMS 36 x RHA 6D-1 and DCMS 43 x DRS 26 were found to be good specific combiners since the *sca* effects of these crosses were in desirable direction for most of the yield contributing characters.

Key Words : Combining Ability, Sunflower, Hybrids, Line X Tester

Sunflower (*Helianthus annuus* L.) was introduced to India in 1969 as an alternate edible oilseed crop in order to bridge the gap of recurring edible oil shortage. However, it gained momentum in commercial cultivation from 1972 onwards with the introduction of four open pollinated varieties *viz.*, EC-68413, EC-68414, EC-68415 and EC-69874 from the erstwhile USSR. Being a highly cross pollinated crop, sunflower is amenable for heterosis breeding. The discovery of cytoplasmic male sterility (Leclercq, 1969) in France and subsequent identification of genes for fertility restoration (Kinman, 1970) in USA are important milestones in sunflower hybrid breeding programme. The first hybrid developed in India using male sterile line was BSH-1 (Seetharam, 1980). Since then, many hybrids were released in sunflower which played a vital role in improving the oil economy. The study of combining ability provides useful information on the nature of gene action as well as assist in selection of parents and hybrids. Accordingly, the present investigation was undertaken to study the type of gene action governing the expression of quantitative traits and to select parents with good *gca* and crosses with good *sca* effects through line x tester analysis in sunflower.

MATERIAL AND METHODS

Four cytoplasmic male sterile lines (DCMS 5, DCMS 18, DCMS 36 and DCMS 43) were crossed with ten testers (DRS 5, DRS 9, DRS 12, DRS 14, DRS 16, DRS 18, DRS 23, DRS 26, RHA 6D-1 and RHA 298) in a line x tester fashion to synthesize 40 hybrids at Directorate of Oilseeds Research (DOR), Hyderabad during *rabi*, 2004-05. The cytoplasmic male sterile lines were developed at DOR by backcross method. The hybrids were evaluated along with their parents in a randomized block design with three replications during summer, 2005. Each line was raised in three rows of 3m length with the spacing between and within rows of 60 and 30 cm, respectively. Recommended agronomic practices were adopted. Observations were recorded on five randomly selected parents from each line in each replication for eight

Table 1 : Analysis of variance for combining ability, proportionate gene action and degree of dominance in sunflower

Source	d.f	Plant height (cm)	Days to 50% flowering	Days to maturity	Head diameter (cm)	Filled seeds per plant	100-seed weight (g)	Seed yield (g/plant)	Oil content (%)
Replications	2	76.74	4.42	4.87	0.76	1332.14	0.06	29.36	13.20
Treatments	53	1160.33**	44.25**	47.21**	16.51**	98687.50**	1.62**	353.66**	49.93**
Parents	13	775.57**	34.48**	38.59**	5.82**	15977.65**	0.77**	80.92**	23.82**
Parents vs. Crosses	1	3345.97**	243.09**	299.42**	281.84**	2351786.00**	23.21**	8968.96**	326.13**
Crosses	39	1232.54**	42.41**	43.62**	13.27**	68485.70**	1.35**	223.66**	56.09**
Lines	3	171.12	187.24**	211.68**	58.87**	286907.18**	3.5	530.25*	241.23**
Testers	9	3419.21**	18.95*	34.55**	33.37**	120679.40**	4.56**	450.51*	130.78
Lines x Testers	27	621.58**	7.74*	10.36**	10.32**	44418.70**	1.22**	145.09**	59.14**
Error	106	157.52	4.20	4.29	1.05	5347.34	0.18	10.62	9.37
σ^2 *gca*		10.02	0.26	0.34	0.14	595.03	0.01	1.64	0.50
σ^2 *sca*		154.68	1.17	2.02	3.09	13023.78	0.34	44.82	16.59
σ^2 *gca*/σ^2 *sca*		0.0648	0.21	0.17	0.04	0.04	0.05	0.03	0.03
Degree of dominance= $\sqrt{\frac{\sigma^2 sca}{\sigma^2 2sca}}$		2.78	1.48	1.71	3.23	3.31	3.02	3.69	4.06

**Significant at 1% level *Signifcant at 5% level

quantitative traits *viz.*, plant height, days to 50 per cent flowering, days to maturity, head diameter, filled seeds per plant, 100-seed weight, seed yield and oil content. The mean values of observations recorded on five random plants were subjected to line x tester analysis (Kempthorne, 1957).

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed the existence of significant differences among the parents *vs* crosses for all the characters studied (Table 1). This clearly connotes the existence of wider genetic diversity among parents and crosses, while the significant variance due to parents *vs* crosses indicated the prevalence of substantial heterosis for all the traits. But, among the lines significant differences were observed for all the characters were except plant height and 100-seed weight. The testers showed significant differences for all the traits except oil content. Interaction between lines and testers also exhibited significant differences for all the traits implying significant contribution of *sca* effects towards the variation among the crosses.

The estimates of variances due to *gca* and *sca* revealed the preponderance of *sca* variance in relation to *gca* variance for all the traits which inferred that all the characters were predominantly under the control of non-additive gene action (Table 1). The result corroborates with the findings of Singh *et al.* (1999) and Madhavi Latha *et al.* (2004). High magnitude of average degree of dominance (> unity) revealed over-dominance for all the traits, confirming the earlier inference drawn about the predominance of non-additive genetic variance in the material, as also reported by Madhavi Latha *et al.* (2004).

The parents with significant negative *gca* effects for plant height, days to 50 per cent flowering, days to maturity and significant

Table 2 : Estimates of general combining ability (*gca*) effects for lines and testers for eight characters in sunflower

Parents	Plant height (cm)	Days to 50% flowering	Days to maturity	Head diameter (cm)	Filled seeds per plant	100-seed weight (g)	Seed yield (g/plant)	Oil content (%)
LINES								
DCMS 5	2.87	-3.10**	-3.35**	0.25	-17.63	-0.26**	-2.30**	-0.17
DCMS 18	3.44	0.12	0.05	0.38*	29.36*	0.12	2.08**	1.11*
DCMS 36	-4.51*	3.02**	3.15**	-0.07	-82.05**	0.16*	-2.67**	-0.57
DCMS 43	-1.80	-0.04	0.15	-0.56**	70.32**	-0.02	2.89**	-0.37
SEi	2.2915	0.3745	0.3782	0.1874	13.3508	0.0783	0.5951	0.5589
TESTERS								
DRS 5	-33.17**	-2.63**	-2.85**	2.30**	83.20**	0.20	5.60**	0.77
DRS 9	3.73	-0.13	0.40	1.92**	117.63**	0.26*	7.15**	-0.32
DRS 12	-10.06**	-0.63	-0.85	0.98**	104.77**	0.03	4.59**	-0.23
DRS 14	-12.47**	0.95	1.15	-0.20	41.62*	0.20	2.79**	-2.09*
DRS 16	6.98	-1.63**	-1.35*	-1.11**	-37.76	0.23	-0.37	-4.82**
DRS 18	26.16**	0.99	1.40*	0.07	-100.58**	-0.97**	-9.96**	3.32**
DRS 23	2.53	-2.26**	-1.85**	0.37	26.49	-0.15	-0.30	0.17
DRS 26	-2.60	-0.05	-1.10	-2.55**	-207.07**	-0.03	-9.85**	-0.14
RHA 6D-1	21.03**	7.28**	6.65**	-1.21**	-41.70*	-0.24	-3.71**	2.44**
RHA 298	-2.12	-1.88**	-1.60**	-0.57	13.39	0.45**	4.04**	0.90
SEj	3.6231	0.5921	0.5980	0.2963	21.1095	0.1237	0.9409	0.8837

** Significant at 1% level * Significant at 5% level

positive *gca* effects for the remaining traits are considered as good general combiners. The characterwise estimation of *gca* effects of lines and testers (Table 2) revealed that the line DCMS 5 and testers, DRS 5, DRS 16, DRS 23 and RHA 298 were early in flowering indicating their utility in breeding for early maturing hybrids. The line DCMS 36 and testers DRS 5, DRS 12 and DRS 14 were of drawf stature indicating the farmers preference for breeding them. The line DCMS 18 was found to be good general combiner as evident by contributing positive alleles through expression of higher means for head diameter, filled seeds/plant, seed yield and oil content. The line DCMS 36 showed significant positive *gca* effect for 100-seed weight. The tester DRS 5 was found to be good general combiner for all the traits except 100-seed weight and oil content. The testers RHA 298 and DRS 18 registered significant positive *gca* effects for 100-seed weight and oil content, respectively. From the overall observations among the lines and testers, none of them proved to be a good general combiner for all the traits. The parents which are good general combiners for yield possessed *gca* effects in the desired direction was also reported by Madhavi Latha *et al.* (2004).

The estimates of *sca* effects (Table 3) showed that no single cross showed maximum *sca* effects for all the characters studied. The crosses which recorded highest significant *sca* effects in desired direction are DCMS 36 x RHA 6 D-1 (earliness), DCMS 18 x DRS 12 (plant height), DCMS 18 x DRS 18 (head diameter), filled seeds/plant and seed yield), DCMS 43 x DRS 18 (100-seed weight) and DCMS 43 x DRS 26 (oil content). However, the crosses, DCMS 5 x DRS 16, DCMS 5 x RHA 6D-1, DCMS 36 x RHA 6D-1 and DCMS 43 x DRS 26 were found to possess desired significant *sca* effects for majority of the characters studied and hence are recommended to be further tested extensively in different agro-climatic zones for their superiority and stability before their release for commercial cultivation. In majority of the

Table 3 : Estimates of specific combining ability (*sca*) effects for eight characters in sunflower

S.No.	Hybrid	Plant height (cm)	Days to 50% flowering	Days to maturity	Head diameter (cm)	Filled seeds per plant	100-seed weight (g)	Seed yield (g/plant)	Oil content (%)
1	DCMS 5 x DRS 5	-5.09	-0.9	-1.65	-1.27*	23.33	0.02	0.60	4.38**
2	DCMS 5 x DRS 9	12.81	0.6	1.60	-1.54**	-53.51	-0.26	-4.70*	2.80
3	DCMS 5 x DRS 12	20.60**	-0.9	-0.15	0.80	121.31**	-0.64*	-0.59	0.97
4	DCMS 5 x DRS 14	14.51*	-1.48	-1.15	-0.76	-15.24	0.14	0.61	-4.46*
5	DCMS 5 x DRS 16	-5.54	-2.90*	-3.15**	2.17**	183.23**	0.01	8.67**	3.52*
6	DCMS 5 x DRS 18	-3.37	-1.52	-0.40	-1.48*	-229.75**	-0.58*	-11.54**	-2.17
7	DCMS 5 x DRS 23	-9.24	0.73	0.85	0.41	69.72	0.55*	7.50**	1.68
8	DCMS 5 x DRS 26	-9.66	1.85	-0.90	0.83	-216.70**	0.26	-8.95**	-8.41**
9	DCMS 5 x RHA 6D-1	-4.89	3.18**	3.35**	1.19*	93.24*	0.75**	9.66**	1.76
10	DCMS 5 x RHA 298	-10.14	1.35	1.60	-0.35	24.37	-0.26	-1.24	-0.05
11	DCMS 18 x DRS 5	-22.19**	0.88	0.45	2.18**	47.82	-0.26	0.33	-0.71
12	DCMS 18 x DRS 9	1.11	-0.62	-0.80	0.30	-38.46	0.28	1.43	-3.22
13	DCMS 18 x DRS 12	-33.00**	-0.12	-0.55	0.50	-26.66	-0.29	-2.91	-4.01*
14	DCMS 18 x DRS 14	-27.19**	0.97	0.45	1.28*	36.50	-0.16	0.21	5.05**
15	DCMS 18 x DRS 16	15.57*	0.88	1.95	-2.44**	-127.79**	0.01	-6.10**	1.36
16	DCMS 18 x DRS 18	10.82	1.76	2.20	4.81**	282.68**	0.30	12.49**	0.84
17	DCMS 18 x DRS 23	13.80	-0.49	-0.55	-1.19*	-43.64	0.21	0.03	0.39
18	DCMS 18 x DRS 26	17.13*	-2.70*	-2.30	-1.38*	-65.24	-0.83**	-7.62**	-1.69
19	DCMS 18 x RHA 6D-1	11.51	-0.70	-1.05	-1.82**	-22.84	0.08	-0.46	-1.08
20	DCMS 18 x RHA 298	12.46	0.13	0.20	-2.25**	-42.38	0.67**	3.04	3.07
21	DCMS 36 x DRS 5	17.63*	0.98	2.35*	-0.70	-43.84	0.62*	3.57	3.77*
22	DCMS 36 x DRS 9	-6.77	0.48	0.10	0.66	66.77	0.46	5.67**	3.05
23	DCMS 36 x DRS 12	4.62	-0.02	-0.65	-0.08	-36.19	0.89**	5.08**	-1.59
24	DCMS 36 x DRS 14	8.63	0.07	0.35	0.22	-8.40	0.57*	3.78*	2.21
25	DCMS 36 x DRS 16	-9.27	0.98	0.85	1.01	26.03	-0.31	-1.16	4.66
26	DCMS 36 x DRS 18	-1.51	0.36	-0.90	-1.17*	-20.68	-1.11**	-7.72**	-4.68**
27	DCMS 36 x DRS 23	5.40	1.11	1.35	-1.05	-73.43	0.02	-3.23	-0.63
28	DCMS 36 x DRS 26	-1.74	0.40	1.60	-0.65	80.39	0.25	4.42*	1.57
29	DCMS 36 x RHA 6D-1	0.23	-3.60**	-4.15**	1.97**	86.61*	-0.94**	-2.92	-1.48
30	DCMS 36 x RHA 298	-5.94	-0.59	-0.90	-0.21	-77.25	-0.43	-7.47**	-3.86*
31	DCMS 43 x DRS 5	9.65	1.03	0.35	-0.22	-27.30	-0.39	-4.49*	-7.43**
32	DCMS 43 x DRS 9	-7.15	-0.47	-0.90	0.58	25.21	-0.48	-2.39	-2.64
33	DCMS 43 x DRS 12	7.77	1.03	1.35	-1.23*	-58.47	0.04	-1.58	4.63**
34	DCMS 43 x DRS 14	4.05	0.45	0.35	-0.74	-12.86	-0.55*	-4.18*	-2.79
35	DCMS 43 x DRS 16	-0.76	-0.97	-1.15	-0.74	-81.47	0.29	-1.41	-6.54**
36	DCMS 43 x DRS 18	-6.42	-0.77	-0.90	-2.16**	-32.26	1.40**	6.77**	6.02**
37	DCMS 43 x DRS 23	0.84	-1.34	-1.65	1.83**	47.35	-0.77**	-4.29*	-1.43
38	DCMS 43 x DRS 26	-5.73	0.45	1.60	1.20*	201.55**	0.33	12.16**	8.53**
39	DCMS 43 x RHA 6D-1	-6.85	1.12	1.85	-1.34*	-157.01**	0.11	-6.28**	0.80
40	DCMS 43 x RHA 298	4.10	-0.72	-0.90	2.81**	95.25*	0.02	5.67**	0.84
	$SE_{(ij)}$	7.2463	1.1843	1.1961	0.5926	42.219	0.2475	1.8818	1.7673

**Significant at 1% level *Signifcant at 5% level crosses, high *sca* effect was due to low x low, high x low and low x high combining parents which further substantiated the operation of non-additive gene action for the characters studied as reported by Singh *et al.* (1999).

Non-additive gene action was predominant in the present investigation for all the important economic traits. The cross with high *sca* effect involving one or both parents with good *gca* can be utilized in heterosis breeding for exploitation of hybrid vigour and to raise the yield levels of sunflower.

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Genetic Divergence in Groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Genetic divergence in 200 genotypes of groundnut belonging to different eco-geographic areas was studied by using Mahalanobis D^2 statistic and principal component analysis (PCA). They were grouped into 12 clusters in case of D^2 analysis and 15 clusters in case of principal component analysis. Clustering pattern of genotypes did not follow geographical origin in both the methods, suggesting that geographical isolation may not be the only factor causing genetic diversity. Hence, selection of parents for hybridization should be more based on genetic diversity rather than geographic diversity. The number of secondaries per plant contributed maximum towards divergence followed by days to maturity and total dry matter per plant. Principal component analysis (PCA) identified three principal components with eigen values more than one which contributed 72.19 per cent of cumulative variance.

Key words : Groundnut, Genetic Divergence, D^2 Statistic, PCA, Ward's Method.

Groundnut (*Arachis hypogaea L.)* a potential oil seed crop and food legume, plays major role in Indian economy. The importance of genetic diversity of parents in a hybridization programme has been much emphasized (Joshi and Dhawan, 1960 and Murthy and Arunachalam, 1966). Genetically diverse parents are likely to produce not only high heterotic effect but also desirable segregants. Therefore, the present investigation was undertaken to study the genetic divergence for yield and other yield component characters in groundnut and to suggest suitable genotypes for use in future breeding programmes.

MATERIAL AND METHODS

The experimental material consisted of 200 genotypes of diverse origin comprising 100 each of Spanish bunch and Virginia bunch habit group, obtained from the germplasm collection being maintained at Agricultural Research Station, Kadiri, Andhra Pradesh. All the genotypes were sown in randomized block design with three replications as contiguous single rows of 2m length during *kharif* 2004. The spacing followed for Spanish bunch habit group was 30 x 15 cm. Observations were recorded on five competitive plants for 14 quantitative characters *viz.,* days to 50% flowering, days to maturity, plant height, number of primaries per plant, number of secondaries per plant, number of mature pods per plant, number of immature pods per plant, pod yield per plant, kernel yield per plant, shelling outturn, 100 kernel weight, total dry matter per plant, harvest index and oil content. D^2 analysis (Mahalanobis, 1928), principal component analysis (Jackson, 1991) and hierarchial cluster analysis (Anderberg, 1993) were carried out using SPSS computer programme.

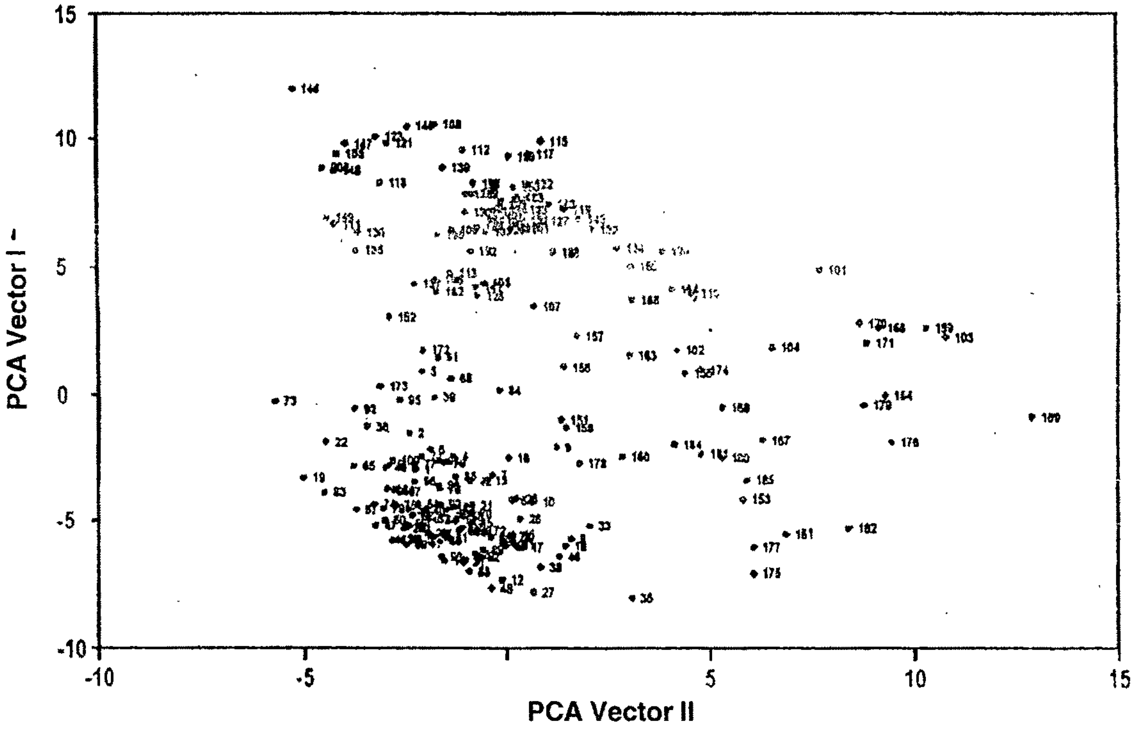
Table 1 : List of genotypes of groundnut employed in the experiment

Sl. no.	Name of the genotype	Sl. no.	Name of the genotype	Sl. no.	Name of the genotype	Sl. no.	Name of the genotype	Sl. no.	Name of the genotype
1	K-1268	41	ICG 7050	81	NAN 181	121	ICG 692	161	ICGV 99083
2	K-1269	42	418	82	S 196	122	ICG 12504	162	ICGV 99084
3	K-1274	43	75-5	83	NANFREDI-118	123	ICG 2846	163	ICGV 99098
4	K-1282	44	KADIRI 4	84	ICGV 86325	124	ICG 635	164	ICGV 98426
5	K-1310	45	F 1-5	85	TG9	125	ICG 13453	165	ICGV 98439
6	K-1319	46	ICG-2796	86	Ah 7322	126	ICG 602	166	X 68-002
7	K-1320	47	ICG 6946	87	RN 4	127	ICG 13392	167	X 176-001-1
8	K-1327	48	7-1	88	Ah 3228	128	ICG 612	168	X 176-001-2
9	K-1333	49	NG-5144	89	416	129	ICG 716	169	X 180-001
10	K-1336	50	RS 149	90	75-59	130	ICG 13042	170	K-1340-1
11	K-1354	51	RS 82	91	BND2-1	131	ICG 2396	171	K-1341-1
12	K-1355	52	ICG 7130	92	ICG-3274	132	ICG 2483	172	TKG 19-A
13	K-1363	53	419	93	TG 3	133	ICG 677	173	TPG 41
14	K-1369	54	AK-12-24	94	ZM 1108	134	ICG 660	174	INS-1-2003-4
15	K-1371	55	NCAC 2672	95	63-106	135	ICG 485	175	K-1467
16	K-1375	56	CHIKKODI	96	NG243	136	ICG 12919	176	K-1468
17	K-1383	57	RPM 189	97	TMV2/EC21137-1	137	ICG 12472	177	K-1469
18	VG9521	58	NCAC 251	98	55-411	138	ICG 706	178	2x 68-002VB
19	TAG24	59	NG 21	99	HG-7-11	139	ICG 617	179	2x 68-002
20	TAG24-1	60	BARBESTON	100	KAIDIRI 5	140	ICG 662	180	5x41-007
21	JL24	61	Ah 7347	101	K-1340-2	141	ICG 12648	181	5x21-033
22	VEMANA	62	RPM 196	102	K-1341-2	142	ICG 1680	182	KADIRI 3
23	K-1271	63	NG-387-B	103	K-1340	143	ICG 622	183	ICG -683
24	Tirupathi-1	64	NCAC 481	104	K-1341	144	IPR 5040	184	X 21-065 Red
25	Tirupathi-2	65	X 07-01	105	Tirupati-3	145	ICG 1653	185	ICGV 99083-1
26	Tirupathi-3	66	#20	106	ICG 648	146	ICG 673	186	ICG 713
27	Narayani	67	MASANI	107	ICG 681	147	ICG 656	187	ICG 12298
28	Kalahasti (TCGS-320)	68	13-10	108	ICG 2249	148	ICG 705	188	ICG 657
29	TMV2	69	N 12	109	ICG 2714	149	ICG 1024	189	ICG 1505
30	DR2	70	411	110	ICG 782	150	ICG 5249	190	ICG 1647
31	HGB	71	ICGV 8300	111	ICG 685	151	TDG 56	191	ICG 2485
32	TMV9	72	ICGV 27	112	ICG 594	152	VB 318	192	ICG 1668
33	K3/CGV 2716	73	NCAC-2820	113	ICG 623	153	TDG 55	193	ICG 645
34	10-5	74	X-1-21-B(E)	114	ICG 13321	154	ICGV 86564	194	ICG 691
35	ICG 7594	75	Ah 3490	115	ICG 631	155	TDG 57	195	ICG 1146
36	NAN 602	76	RS 30	116	ICG 652	156	ICGV 98393	196	ICG 655
37	EC 1676	77	NCAC 2820	117	ICG 689	157	ICGV 98406	197	ICG 658
38	NC 1308	78	K-153	118	ICG 667	158	ICGV 98409	198	ICG 808
39	TDG 58	79	RS 118	119	ICG 704	159	ICGV 99073	199	ICG 706
40	J11	80	RPM 691	120	ICG 682	160	ICGV 99082	200	ICG 715

1-100 = Spanish bunch habit group

101-200 = Virginia bunch habit group

Fig 1 : Two dimensional graph showing relative position of genotypes of groundnut (*Arachis hypogaea* L.) based on PCA scores



RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the 200 genotypes indicating that the existence of substantial genetic variability for all the traits under study. On the basis of D^2 analysis, the 200 genotypes were grouped into 12 clusters (Table 2). The maximum number of genotypes (84) were included in cluster I. Cluster II, III, IV and V had 51, 25 18 and 15 genotypes, respectively and the remaining clusters had one genotype each. The pattern of distribution of genotypes into various clusters was at random suggesting that the genetic diversity was not related to geographic diversity. There are forces other than geographical separation which are responsible for diversity such as natural and artificial selection, exchange of breeding material, genetic drift and environmental variation (Murthy and Arunachalam, 1966). Similar Results were also reported by Yadava *et al.* (1991) Venkataravana *et al.* (2000) and Chowdhary *et al.* (2000).

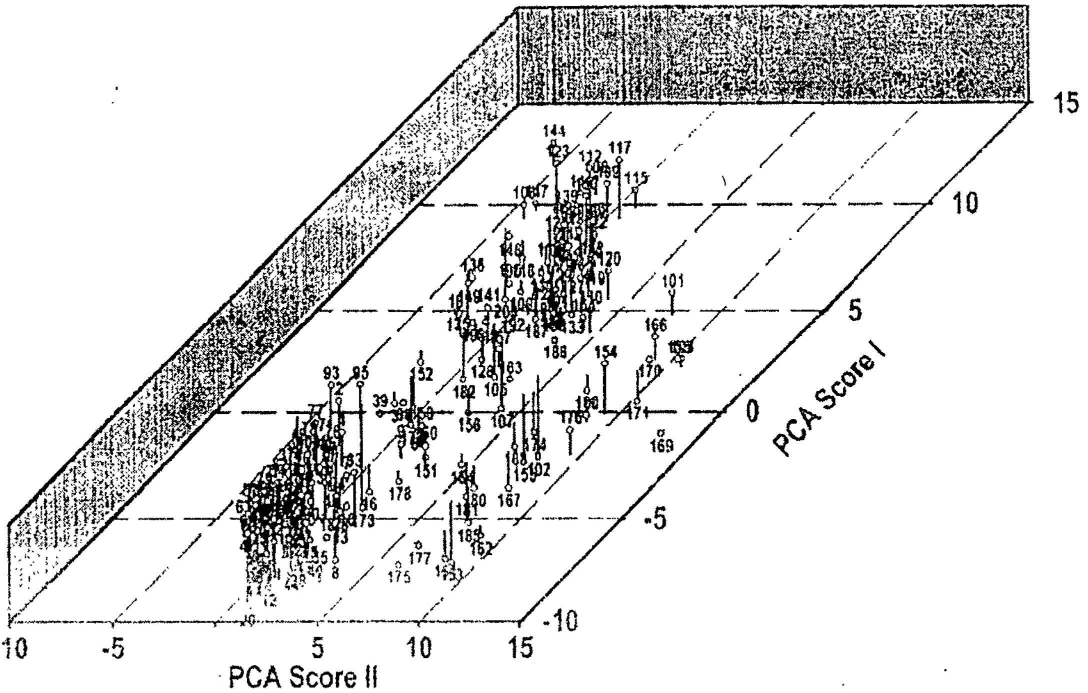
Average intra-and inter-cluster D^2 values are presented in Table 3. Cluster V recorded the highest intra-cluster distance (505.45) and it was the lowest (0.00) in clusters VI, VII, VIII, IX, X, XI and XII, all being single genotype clusters. The average inter-cluster distance was maximum between cluster XI and cluster XII (2886.49) followed by cluster VII and cluster XII (2624.09).

Table 2 : Distribution of 200 genotypes of groundnut (*Arachis hypogaea* L.) in different clusters in case of D^2 analysis

S.no.	Cluster no.	Name of the genotypes	Number of genotypes
1	I	HG8 (SB), J11 (SB), TMV2/EC21137-1 (SB), ICGV 7050 (SB), Chikkodi (SB), Tirupathi-2 (SB), RS 118 (SB), Kadiri 5 (SB), X-1-21B (E) (SB), AK 12-24 (SB), Masani (SB), NG 21 (SB), Ah 3228 (SB), NCAC 2672 (SB), AH 7322 (SB), 416 (SB), RPM 196 (SB), NG 387-B (SB), S196 (SB), ICG7130 (SB), Ah7341 (SB), RS82 (SB), 419 (SB), RPM189 (SB), TMV2 (SB), 75-59 (SB), M2 (SB), HG7-11 (SB), 75-5 (SB), NC1308 (SB), BARBESTON(SB), RS149 (SB), NG5144 (SB), K-1268 (SB), 55-411 (SB), NCAC251 (SB), NCAC481 (SB), 10-5 (SB), TV9 (SB), K-1383 (SB), K-1355 (SB), 7-1 (SB), Kalahasti (TCGS-320) (SB), TG9 (SB), NCAC 2675 (SB), Tirupathi-1 (SB), RPM691 (SB), NANFREDI-118 (SB), RN4 (SB), NAN 81 (SB), ICG3274 (SB), Ah 3490 (SB), 411 (SB), ICGV8300 (SB), Tirupathi-4 (SB), RS30 (SB), JL24 (SB), K-1310 (SB), ZM1108 (SB), NAN602 (SB), ICG7594 (SB), K-1369 (SB), NG243 (SB), K-1354 (SB), ICG6946 (SB), NCAC2820 (SB), K-1371 (SB), TG3 (SB), #20 (SB), K-1336 (SB), K-1333 (SB), K-1327 (SB), 63-106 (SB), FI-5 (SB), 418 (SB), K-1269 (SB), ICG2796 (SB), K3/ICGV2716 (SB), Narayani (SB), K-1282 (SB), K-1320 (SB), K-1274 (SB), DR2 (SB)	84
2	II	ICG706 (VB), ICG1680 (VB), ICG706 (VB), ICG2249 (VB), ICG683 (VB), ICG645 (VB), ICG660 (VB), ICG1647 (VB), ICG622 (VB), ICG1146 (VB), ICG2485 (VB), ICG617 (VB), ICG691 (VB), ICG662 (VB), ICG667 (VB), ICG12504 (VB), ICG692 (VB), ICG716 (VB), ICG2396 (VB), ICG13392 (VB), ICG631 (VB), ICG602 (VB), ICG635 (VB), ICG652 (VB), ICG13042 (VB), ICG1668 (VB), ICG13453 (VB), ICG617 (VB), ICG2714 (VB), ICG713 (VB), ICG655 (VB), ICGV98439 (VB), ICG658 (VB), ICG705 (VB), ICG656 (VB), ICG623 (VB), ICG13321 (VB), ICG485 (VB), ICG12298 (VB), ICG677 (VB), ICG648 (VB), ICG1024 (VB), ICG704 (VB), ICG657 (VB), ICG682 (VB), ICG673 (VB), Tirupati-3 (VB), ICGG12472 (VB), K-1341 (VB), ICG689 (VB), ICG5249 (VB)	51
3	III	TAG24 (SB), TAG25-1 (SB), KADIR-4 (SB), X07-01 (SB), K-1363 (SB), K-1271 (SB), BND2-1 (SB), 13-10 (SB), K-1319 (SB), ICGV86325 (SB), K-1375 (SB), TDG56 (VB), VG9521 (SB) K-153 (SB), Vemana (SB), ICGV98393-1 (VB), TPG41 (VB), TDG57 (VB), Kadiri3 (VB), TKG19-A (VB), ICGV99083 (VB), ICGV 48409 (VB), TDG55 (VB), Sx21-033 (VB), ICG612 (VB)	25
4	IV	X 176-001-1 (VB), X176-001-2 (VB), ICGV99083 (VB), ICGV99084 (VB), ICGV99082 (VB), ICGV98406 (VB), ICGV99098 (VB), ICGV98426 (VB), 5x41-007 (VB), X21-065 Red (VB), K-1467 (VB), k-1341-2 (VB), INS-1-2003-4 (VB), ICG681 (VB), ICG12648 (VB), ICG12919 (VB), ICG808 (VB), ICG 685	18
5	V	ICG594 (VB), ICG2846 (VB), ICG2483 (VB), ICG1653 (VB), ICG782 (VB), K-1340-2 (VB), K-1340 (VB), ICGV86534 (VB), K-1341-1 (VB), K-1468 (VB), ICGV99073 (VB), X180-001 (VB)	15
6	VI	K-1469 (VB)	1
7	VII	RPM5040 (VB)	1
8	VIII	2X68-002VB (VB)	1
9	IX	ICG715 (VB)	1
10	X	EC1676 (SB)	1
11	XI	VB318 (VB)	1
12	XII	TDG58 (SB)	1

VB = Virginia bunch habit group SB = Spanish bunch habit group

Fig 2 : Three dimensional graph showing relative position genotypes of groundnut (*Arachis hypogaea* L.) based on PCA scores



Thus, hybrids between genotypes belonged to these clusters may result in maximum hybrid vigour and eventually desirable segregants for development of useful genetic stocks and varieties, as also suggested by Yadava *et al.* (1991), Chowdhary *et al.* (2000) and Venkataravana *et al.* (2000).

The knowledge on characters influencing divergence is an important aspect to a breeder which can be estimated by D^2 analysis. The number of secondaries per plant (30.46) contributed maximum towards divergence followed by days to maturity (27.52%) and total dry matter per plant (11.61%), (Table 4).

Principal Component Analysis (PCA) identified three principal components with eigen values with more than one which contributed 72.19 per cent of cumulative variance. The first principal component (PC_1) contributed maximum towards variability (39.20%) with significant loading of days to 50% flowering (0.865), number of secondaries per plant (0.859), days to maturity (0.813) and number of primaries per plant (0.787) which were positively correlated and oil content (-0703), harvest index (-0.690), mature pods per plant (-0.689) and shelling outturn (-0.607) which were negatively correlated. The second principal component (PC_2), which described 24.07 per cent of the total variance and it reflected significant

Table 3 : Average intra-and inter-cluster distances for 12 clusters formed by 200 genotypes of groundnut (*Arachis hypogaea* L.) in case of D^2 analysis

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	155.50 (12.47)	1286.53 (35.86)	504.42 (22.45)	818.55 (28.61)	1507.12 (38.82)	332.11 (18.22)	2438.55 (49.38)	371.69 (19.28)	1504.66 (38.79)	428.25 (20.90)	962.36 (31.02)	1100.77 (33.17)
II		235.49 (15.34)	1036.26 (32.19)	714.93 (26.73)	547.57 (23.40)	1283.72 (35.83)	516.22 (22.72)	1202.67 (34.68)	679.47 (26.07)	1513.41 (38.90)	1406.32 (37.50)	1718.13 (41.45)
III			384.65 (19.61)	593.14 (23.73)	1395.10 (37.35)	614.77 (24.79)	2141.90 (46.28)	627.63 (25.05)	974.06 (31.21)	874.49 (29.57)	930.15 (30.49)	1351.13 (36.76)
IV				478.63 (21.87)	912.52 (30.20)	707.96 (26.60)	1576.44 (39.70)	853.88 (29.22)	887.68 (29.79)	1020.14 (31.94)	1000.38 (31.63)	1584.19 (39.80)
V					505.45 (22.48)	1192.10 (34.52)	1026.65 (32.04)	1267.12 (35.59)	1303.97 (36.11)	1707.70 (41.32)	1801.12 (42.44)	1891.62 (43.49)
VI						0.00 (0.00)	2513.61 (50.13)	354.56 (18.83)	1566.88 (39.58)	513.97 (22.67)	1175.37 (34.28)	942.57 (30.70)
VII							0.00 (0.00)	2483.07 (49.83)	1123.51 (33.52)	2406.99 (49.06)	2376.38 (48.75)	2624.09 (51.23)
VII								0.00 (0.00)	1534.25 (39.17)	772.17 (27.78)	1033.20 (32.14)	1123.65 (33.52)
IX									0.00 (0.00)	1459.97 (38.20)	808.97 (28.44)	2399.26 (48.98)
X										0.00 (0.00)	754.15 (27.46)	1436.76 (37.91)
XI											0.00 (0.00)	2886.49 (53.72)
XII												0.00 (0.00)

Figures in parentheses are D^2 values

Table 4 : Contribution of 14 characters towards genetic divergence in 200 genotypes of groundnut. (*Arachis hypogaea* L.)

Character	Days 50% flowering	Days to maturity	Plant height (cm)	No.of primaries/ plant	No secon-daries/ plant	No.of mature pods/ plant	No immature pods/ plant	Pod yield/ plant (g)	Kernel yield per plant (g)	Shelling outturn (%)	100 kernel weight (g)	Total dry matter / plant (g)	Harvest index	Oil content (%)
% Contribution towards divergence	0.55	27.52	4.99	1.08	30.46	6.49	3.48	3.11	1.25	1.69	6.51	11.61	1.12	0.15

Table 5 : Eigen values, proportion of the total variance represented by first four principal components, cumulative per cent variance and component loading of different characters in groundnut (*Arachis hypogaea* L.)

	PC_1	PC_2	PC_3	PC_4
Eigen value	5.49	3.37	1.25	0.89
% Variance explained	39.20	24.07	8.92	6.33
Cum. variance explained	39.20	63.26	72.19	78.52
Days to 50% flowering	0.865	0.280	0.020	0.000
Days to maturity	0.813	0.398	0.197	0.018
Plant height (cm)	-0.390	-0.045	-0.748	0.300
No.of primaries/plant	0.787	0.438	0.078	-0.100
No.of secondaries/plant	0.859	0.255	-0.148	-0.114
No.of mature pods/plant	-0.689	0.464	-0.132	-0.291
No.of immature pods/plant	-0.450	0.146	0.141	0.508
Pod yield/plant (g)	-0.414	0.889	-0.041	-0.016
Kernel yiled/plant (g)	-0.501	0.845	0.008	-0.094
Shelling-outturn (%)	-0.607	-0.006	0.279	-0.328
100 Kernel weight (g)	0.337	0.539	0.347	0.518
Total drymatter/plant (g)	0.134	0.797	-0.486	-0.018
Harvest index	-0.690	0.452	0.370	-0.040
Oil content (%)	-0.703	-0.072	0.100	0.208

loadings of pod yield per plant (0.889), kernel yield per plant (0.845), total drymatter per plant (0.797) and 100-kernel weight (0.539). All characters loaded in PC_2 were positively correlated. The third principal component (PC_3) was characterized by conspicuously high loading of plant height (-0.748) and was negatively correlated (Table 5). The population with high PC_1 values characterized by more vegetative growth, low oil content, harvest index and shelling out turn and less number of mature pods per plant and the population with high PC_2 values were characterized by high pod yield per plant, kernel yield per plant, total dry matter per plant and 100 kernel weight.

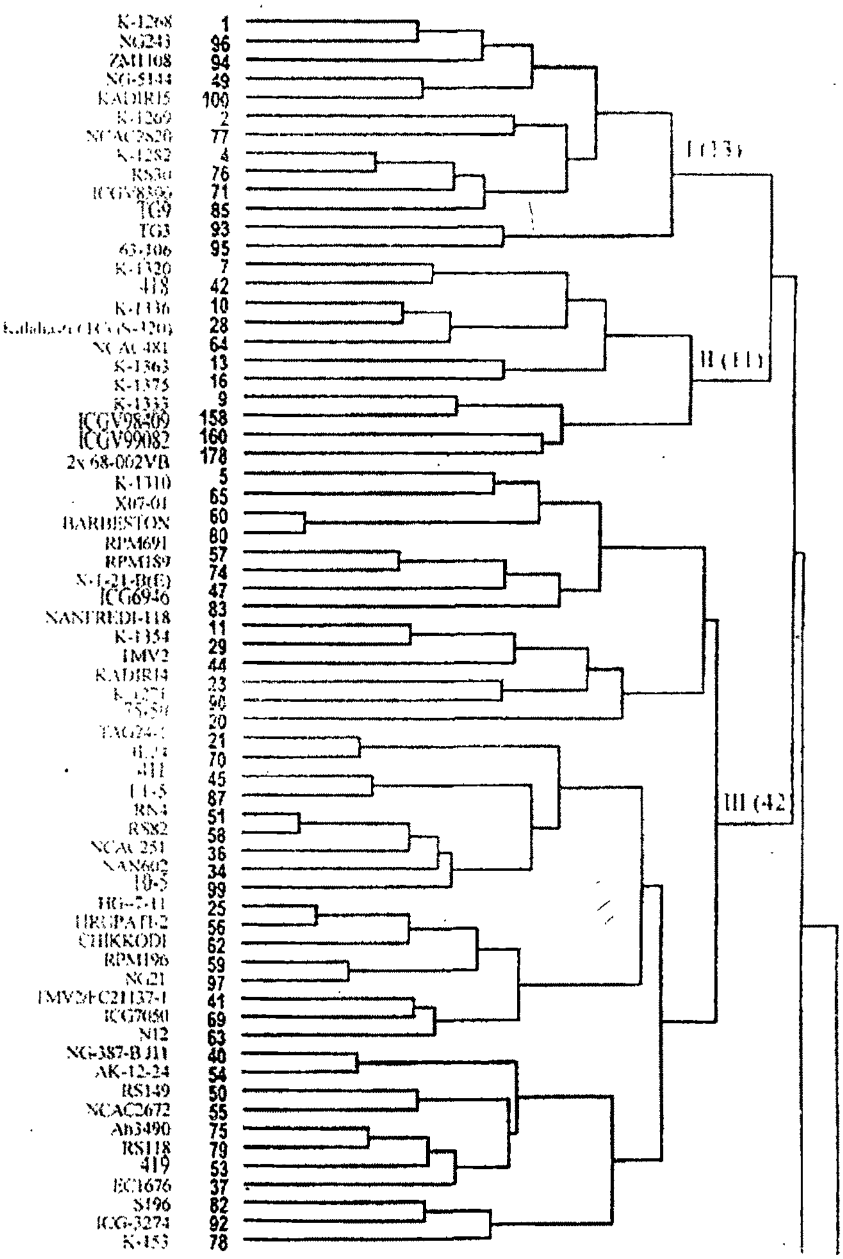
Based on these first three principal components, mean genotype scores or PCA scores were computed. Principal factor scores (PF scores) for all the 200 genotypes were estimated in all the 3 PC's and utilized to construct precise 2D and 3D plots (Fig 1&2). All the genotypes (names and numbers assigned are given in Table 1) were plotted for PC_1, PC_2 and PC_3, which cumulatively explained 72.19 variability and accounted for all the characters. IPR 5040, ICG 673, ICG2249, ICG2846 were clustering towards positive side of PC 1 axis. The plot of PC_1 PC_2 and PC_3 showed clear differentiation of genotypes according to their cluster membership for each cluster. Genotypes belonging to a common cluster have fallen nearer to each other and vice-versa. This was confirmed by cluster analysis. The mean scores of genotypes were used as input for clustering in order to group the genotypes into various clusters. Hierarchical clustering procedure (i.e. Ward's method) was followed to group the genotypes. On the basis of Ward's method 200 genotypes were grouped into 15 clusters (Table 6). The distribution of genotypes into various clusters

Table 6 : Distribution of 200 genotypes of groundnut (*Arachis hypogaea* L.) into 15 clusters in case of Ward's method

S.No.	Cluster No.	Name of the Genotypes	Number of genotypes
1	I	K-1268 (SB), NG243 (SB), ZM1108 (SB), NG-5144 (SB), Kadiri 5 (SB), K-1269 (SB), NCAC2820 (SB), K-1282 (SB), RS30 (SB), ICGU8300 (SB), TG9 (SB), TG3 (SB), 63-106 (SB)	13
2	II	K-1320 (SB), 418 (SB), K-1336 (SB), Kalahasti (SB), NCAC481 (SB), K-1363 (SB), K-1375 (SB), K-1333 (SB), ICGV98409 (VB), ICGV 99082 (VB), 2X68002 (VB)	11
3	II	K-1310 (SB), X07-01 (SB), BARABESTON (SB), RPM691 (SB), RPM189 (SB), X-1-21B(E) (SB), ICG6946 (SB), NANFREDI-118 (SB), K-1354 (SB), TMV2 (SB), Kadiri 4 (SB), K-1271 (SB), 75-59 (SB), TAG 24-1 (SB), JL 24 (SB), 411 (SB), F_1-5 (SB), RN4 (SB), RS 82 (SB), NCAC251 (SB), NAN 602 (SB), 10-5 (SB), HG-7-11 (SB), Tirupathi-2 (SB), Chikkodi (SB), RPM 196 (SB), NG 21 (SB), TMV2/EC 211237-1 (SB), ICG 7050 (SB), N 12 (SB), NG-387-B (SB), J11 (SB), AK-12-24 (SB), RS149 (SB), NCAC2672 (SB), Ah3490 (SB), RS118 (SB), 419 (SB), EC1676 (SB), S196 (SB), ICG 3274 (SB), K-153 (SB)	42
4	IV	K-1319 (SB), DR2 (SB), TAG24 (SB), Vemana (SB), NCAC2675 (SB), TPG41 (VB)	6
5	V	K-1355 (SB), 5-1 (SB), K-1369 (SB), 55-411 (SB), HG8 (SB), ICG7130 (SB), K-1371 (SB), K-1383 (SB), 75-5 (SB), Ah 7321 (SB), Tirupati-1 (SB), ICGV27 (SB), NC1308 (SB), ICG 2796 (SB), VG9521 (SB), K-1327 (SB), ICG7594 (SB), TMV9 (SB), 416 (SB), Masani (SB), Ah 3228 (SB), Ah7322 (SB), #20 (SB), NANI81 (SB), Tirupati-4 (SB), K3/ICGV21761 (SB), ICGV 2716 (SB), Narayani (SB)	27
6	VI	K-1340 (VB), ICGV99073 (VB), X68-002 (VB), K-1340-1 (VB), K1341-1 (VB), K-1340-2 (VB), K-1468 (VB), 2X68-002 (VB), ICGV86564 (VB), X180 (VB)	10
7	VII	TDG55 (VB), ICGV99083-1 (VB), 5X41-007 (VB), 5X21-003 (VB), X21-065 Red (VB), X176-001-1 (VB), ICGV 99083 (VB), ICGV 99084 (VB), K-1467 (VB), K-1469 (VB)	10
8	VII	K-1274 (SB), 13-10 (SB), BND-1 (SB), TKG19-A (VB), VB318 (VB), Tirupati-3 (VB), Kadiri3 (VB), ICG612 (VB), ICG681 (VB), ICG623 (VB), ICG808 (VB), ICG12472 (VB), ICG12648 (VB)	14
9	IX	ICGV86325 (SB), ICGV8393 (VB), TDG56 (VB), ICGV98406 (VB), ICGV99098 (VB)	5
10	X	K-1341 (VB), TDG57 (VB), X176-001-2 (VB), INS-1-2003-4 (VB), K-1341 (VB).	5
11	XI	ICG82 (VB), ICGV98426 (VB), ICG657 (VB), ICG660 (VB), ICGV98439 (VB), ICG682 (VB)	6
12	XII	ICG648 (VB), ICG656 (VB), ICG705 (VB), ICG667 (VB), ICG692 (VB), ICG673 (VB), ICG2249 (VB), ICG2846 (VB), IPR5040 (VB)	9
13	XII	ICG685 (VB), ICG1024 (VB), ICG485 (VB), ICG12919 (VB), ICG715 (VB)	5
14	XIV	ICG2714 (VB), ICG1146 (VB), ICG1668 (VB), ICG13042 (VB), ICG662 (VB), ICG1332 (VB), ICG1505 (VB), ICG2396 (VB), ICG12298 (VB), ICG677 (VB), ICG13392 (VB), ICG2485 (VB), ICG704 (VB), ICG713 (VB), ICG655 (VB), ICG622 (VB), ICG1653 (VB), ICG2483 (VB)	18
15	XV	ICG652 (VB), ICG691 (VB), ICG1647 (VB), ICG602 (VB), ICG635 (VB), ICG1680 (VB), ICG-683 (VB), ICG12504 (VB), ICG5249 (VB), ICG645 (VB), ICG716 (VB), ICG658 (VB), ICG13453 (VB), ICG706 (VB), ICG617 (VB), ICG689 (VB), ICG594 (VB), ICG631 (VB)	19

VB = Virginia bunch habit group SB = Spanish bunch habit group

Fig 3 : Ward's minimum variance dendrogram formed by 200 genotypes of groundnut (*Arachis hypogaea* L.)



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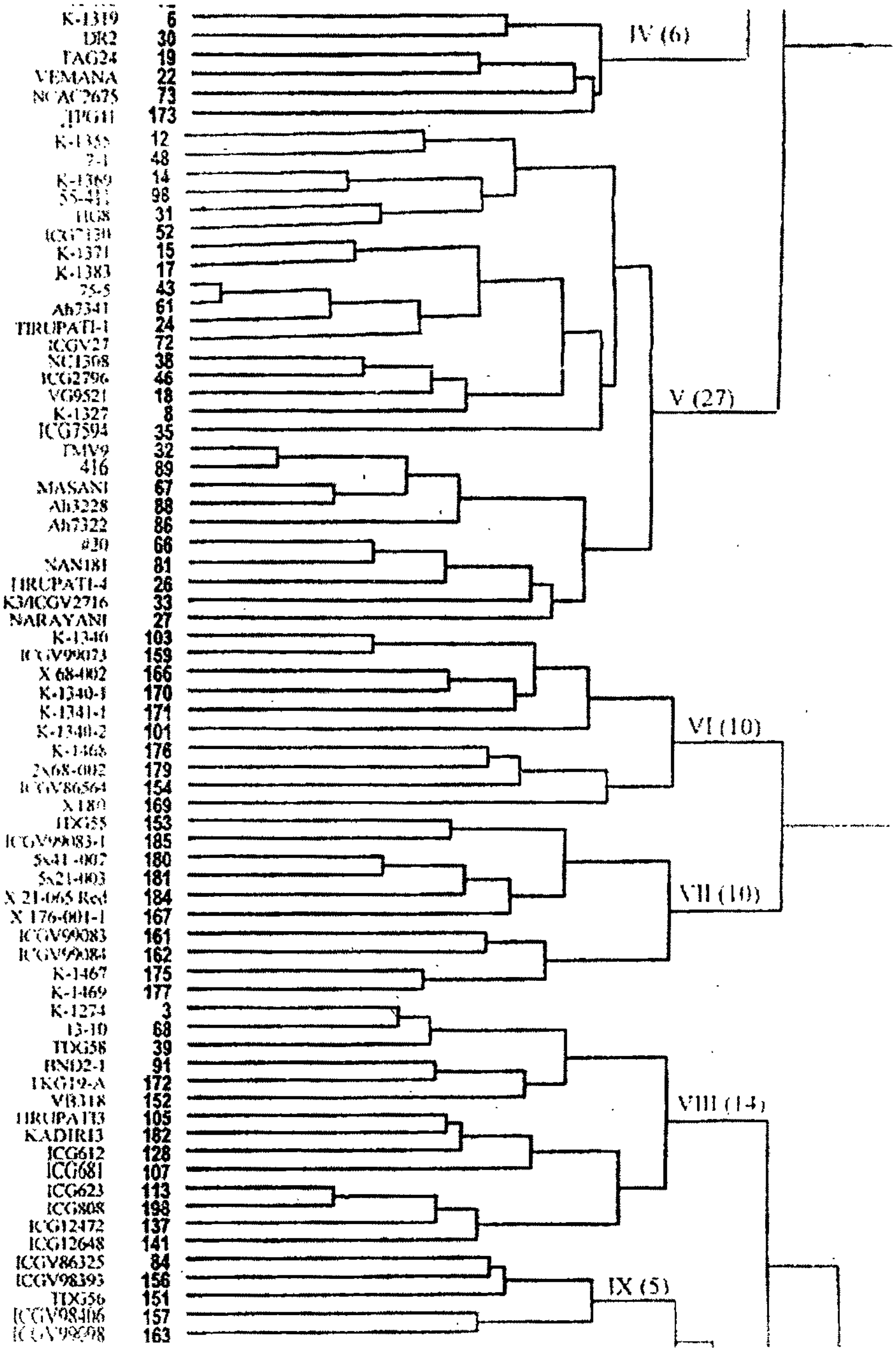
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ICG7130 52
K-1371 15
K-1383 17
75-5 43
Ah7341 61
TIRUPATI-1 24
ICGV27 72
NC1308 38
ICG2796 46
VG9521 18
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ICG7594 35
TMV9 32
416 89
MASANI 67
Ah3228 88
Ah7322 86
#30 66
NAN181 81
TIRUPATI-4 26
K3/ICGV2716 33
NARAYANI 27
K-1340 103
ICGV99023 159
X 68-002 166
K-1340-1 170
K-1341-1 171
K-1340-2 101
K-1468 176
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5x21-003 181
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VB318 152
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TIX56 151
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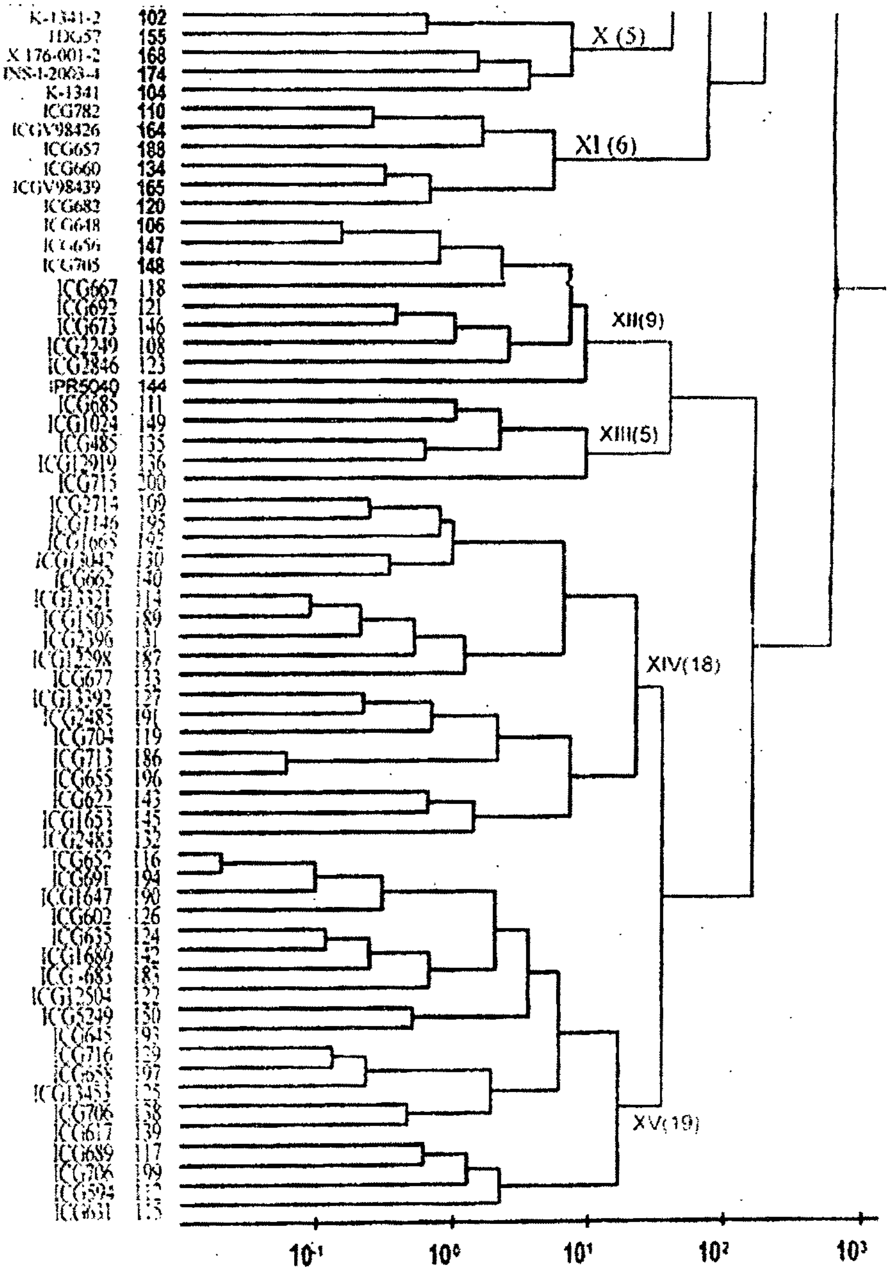
VII (10)
VIII (14)
IX (5)

(Contd............Fig 3)



Roman No. indicates Cluster No.
Figures in parentheses are number of genotypes

Table 7 : Average intra-and inter-cluster Euclidean^2 for 15 clusters formed by 200 genotypes of groundnut (*Arachis hypogaea* L.)

Cluster	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX	Cluster X	Cluster XI	Cluster XII	Cluster XIII	Cluster XIV	Cluster XV
ClusterI	3.59	14.54	10.82	23.87	25.72	162.73	81.80	38.91	31.01	78.24	86.46	156.09	98.20	91.90	115.83
ClusterII		5.49	15.69	36.35	16.59	109.51	37.87	47.76	21.23	44.27	73.51	189.39	126.97	97.41	129.38
ClusterIII			4.77	28.46	12.66	185.39	75.80	67.69	50.17	94.63	126.62	221.13	145.66	138.93	172.45
ClusterIV				10.56	56.29	210.57	116.63	37.14	46.31	93.75	111.56	144.00	77.87	93.05	120.95
ClusterV					6.10	159.62	50.56	96.55	59.26	89.39	137.23	279.21	198.52	170.85	210.49
ClusterVI						14.66	56.16	136.75	76.07	35.46	54.96	250.82	228.63	123.12	149.83
ClusterVII							11.05	113.07	51.90	34.28	91.63	291.84	227.71	152.44	194.99
ClusterVII								9.86	20.65	54.30	37.30	61.02	29.77	23.34	36.81
ClusterIX									7.14	20.47	25.21	112.48	73.68	39.65	61.53
ClusterX										6.29	27.84	161.98	124.01	61.58	90.20
ClusterXI											3.22	80.55	71.83	19.92	29.42
ClusterXII												5.69	17.02	30.49	18.14
ClusterXIII													6.42	24.84	24.40
ClusterXIV														5.40	8.33
ClusterXV															4.13

Figures in parentheses are D^2 values

was random, indicating lack of parallelism between gentic and geographic diversity as in case of D^2 analysis.

Cluster III was the largest comprising 42 genotypes followed by cluster V (25) and cluster XV (19). The average intra- and inter-cluster distance (Euclidean^2 distance) are presented in Table 7. Cluster VI had maximum intra-cluster distance (14.66) followed by cluster VII (11.05) and cluster IV (10.56). The inter-cluster distance varied from 8.33 (between cluster XIV and XV) to 291.84 (between clusters VII and XII). Maximum inter-cluster distance was observed between clusters VII and XII (291.84) followed by clusters V and XII (279.21) and between clusters VI and XII (9250.82). Based on these studies, it could be inferred that crosses can be planned between the genotypes of these clusters to obtain better and desirable segregants. Utilization of principal component analysis combined with hierarchial cluster analysis in gentic diversity studies was reported earlier also by Altaher and Singh (2003) in cotton and Subramanian and Muthiah (2003) in greengram and blackgram.

D^2 analysis grouped the 200 genotypes into 12 clusters, where as principal component analysis grouped into 15 clusters. The pattern of distribution of genotypes into different clusters was at random in both methods. Further, clustering pattern for genotypes in both clustering methods was not the same. In broad sense the two methods of classifying genotypes into different groups is equally useful but hierarchial cluster analysis has additional advantage of identifying sub-clusters of the major groups at different levels so that each small group can be critically analyzed.

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Diallel Analysis in Roselle (*Hibiscus sabdariffa* L.)

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ABSTRACT

An 8 x 8 diallel (excluding reciprocals) along with parents was studied for fibre yield and eight yield component characters in roselle (*Hibiscus sabdariffa* L.). All parents with high per se performance recorded high positive *gca* effects and all crosses with high values of *per se* performance exhibited highly significant positive *sca* effects for fibre weight per plant indicating the role of both additive and non-additive gene actions in governing the fibre yield

Key words : Diallel Analysis, Roselle (*Hibiscus sabdariffa* L.)

Roselle [*Hibiscus sabdariffa* L.] is an important bast fibre yielding crop in India. There is every possibility of increasing the average fibre yield of roselle. Diallel analysis is one of the powerful tools available to determine gene action and estimate both general and specific combining ability effects of parents and hybrid combinations, respectively. Therefore, the present study in roselle to reveal the type of gene action controlling the traits and to suggest best combiners for future breeding programmes.

MATERIAL AND METHODS

The experimental material for the present investigation comprised 28 F_1's derived through diallel system of mating (excluding reciprocals) involving 8 genotypes *viz.,* AR-3, AR-6, AR-7, AR-13A, AR-21, AR-30, AR-45 and AR-50 chosen based on their morphological characters and genetic divergence from different clusters of D^2 analysis. The F_1 seed of 28 crosses was obtained along with parents and two standard checks [AMV1 and AMV2] and were sown in a randomized block design with three replications. Data on plant height, basal stem diameter, number of nodes per plant, internodal length, fresh weight per plant, fibre length, fibre wood ratio, days to 50% flowering and fibre weight per plant were recorded on ten randomly selected plants from each entry. Diallel analysis method II model 1 (Griffing, 1956) was employed to assess the combining ability of eight parents and their F_1 population.

RESULTS AND DISCUSSION

The mean of parents and crosses for nine characters in roselle are presented in Table 1. The results of analysis of variance for combining ability in respect of nine characters are furnished in Table 2. The *gca* effects of eight parents and *sca* effects for 28 crosses in respect of 9 characters are presented in Table 3 and 4, respectively.

Mean squares of *gca* and *sca* were highly significant for all the characters, indicating that both additive and non-additive gene actions are involved in controlling these characters in kenaf (Mohan Rao, 1994) and (Alam and De, 1995) in jute. The results indicate that high *per se* performance and high *gca* need not necessarily give high *sca* effects.

Table 1 : Mean performance of parents and crosses for nine characters in roselle

Parents	Plant height (cm)	Basal stem diameter (cm)	No.of nodes/ plant	Internodal length (cm)	Days to 50% flowering	Fresh weight/ plant (g)	Fibre length (cm)	Fibre-wood ratio	Fibre weight/ plant (g)
AR-3	196.56	1.07	36.26	5.62	125.66	199.66	160.76	0.45	5.67
AR-6	205.80	1.43	37.23	5.24	124.00	263.66	201.20	0.31	7.57
AR-7	211.46	1.21	42.00	5.80	121.33	182.00	191.63	0.41	5.54
AR-13A	201.40	1.24	36.10	5.23	119.00	184.50	195.96	0.53	6.03
AR-21	218.46	1.62	39.66	5.80	122.66	289.33	199.93	0.38	7.82
AR-30	203.56	1.10	41.63	4.20	122.66	200.66	193.36	0.42	6.54
AR-45	196.10	1.02	35.90	5.77	123.33	207.50	161.30	0.50	5.83
AR-50	206.83	1.43	44.63	5.17	123.00	301.33	180.60	0.38	8.22
AMV-1 (Check)	216.56	1.54	38.16	5.21	119.66	280.66	200.23	0.38	8.56
AMV-2 (Check)	215.10	1.41	36.40	5.28	122.33	274.50	199.73	0.36	8.18
Mean of parents	205.02	1.26	39.17	5.35	123.20	228.58	185.59	0.42	6.65
Range of parents	196.10-218.47	1.02-1.62	35.90-44.63	4.20-5.80	119.00-126.67	182.00-301.33	160.77-201.20	0.31-0.53	5.54-8.22
Crosses									
AR-3 x AR-6	232.00	1.36	38.63	5.42	123.00	288.00	199.83	0.53	9.26
AR-3 x AR-7	187.66	1.36	35.03	5.69	120.66	247.50	156.93	0.52	8.96
AR-3 x AR-13A	228.16	1.29	40.70	5.26	120.33	179.16	205.56	0.42	5.62
AR-3 x AR-21	192.06	1.53	31.90	5.65	123.33	250.50	172.63	0.60	9.23
AR-3 x AR-30	210.03	1.26	39.33	4.23	124.66	189.90	193.46	0.35	5.92
AR-3 x AR-45	237.03	1.43	39.46	5.37	123.33	273.50	192.36	0.52	9.13
AR-3 x AR-50	182.86	1.51	34.20	5.35	122.33	238.66	164.10	0.51	8.73
AR-6 x AR-7	243.96	1.58	45.30	5.62	121.66	298.33	226.40	0.48	8.43
AR-6 x AR-13A	204.50	1.16	38.23	4.74	118.33	196.33	192.63	0.37	5.45
AR-6 x AR-21	248.76	1.59	44.26	5.68	121.00	298.66	231.26	0.50	9.08
AR-6 x AR-30	182.20	1.45	34.86	5.16	123.33	269.83	160.06	0.57	8.39
AR-6 x AR-45	206.06	1.26	39.33	5.55	121.00	196.66	192.86	0.36	6.72
AR-6 x AR-50	207.93	1.19	39.36	5.09	121.66	181.16	187.33	0.41	6.26
AR-7 x AR-13A	245.90	1.37	43.46	5.04	119.33	141.66	220.03	0.26	4.57
AR-7 x AR-21	243.26	1.65	45.56	5.65	121.00	327.16	231.26	0.50	9.04
AR-7 x AR-30	205.00	1.16	39.26	5.14	125.33	196.83	198.46	0.33	6.63
AR-7 x AR-45	204.86	1.21	38.26	5.77	120.66	208.33	193.73	0.41	6.39
AR-7 x AR-50	204.93	1.15	39.30	5.27	120.33	203.33	193.06	0.41	5.50
AR-13A x AR-21	233.86	0.99	42.53	5.63	120.00	147.00	222.06	0.29	4.41
AR-13A x AR-30	171.40	1.15	33.33	5.09	124.66	202.50	155.93	0.42	5.73
AR-13A x AR-45	248.90	1.11	45.06	5.85	120.33	147.83	237.23	0.29	4.66
AR-13A x AR-50	202.10	1.21	37.46	4.91	119.33	191.66	182.20	0.37	6.16
AR-21 x AR-30	208.23	1.22	38.96	5.97	126.00	196.33	181.70	0.38	6.21
AR-21 x AR-45	198.30	1.18	39.26	5.69	121.00	196.16	161.46	0.35	6.35
AR-21 x AR-50	194.36	1.03	38.36	5.12	122.00	153.33	179.96	0.26	4.40

(Contd.........)

(Table 1 Contd.......)

Crosses	Plant height (cm)	Basal stem diameter (cm)	No.of nodes/ plant	Internodal length (cm)	Days to 50% flowering	Fresh weight/ plant (g)	Fibre length (cm)	Fibre-wood ratio	Fibre weight/ plant (g)
AR-30 x AR-45	194.73	1.17	32.50	5.09	125.33	199.00	157.93	0.37	6.48
AR-30 x AR-50	201.20	1.21	38.76	5.08	125.00	197.66	187.26	0.36	5.73
AR-45 x AR-50	251.73	1.01	46.33	5.53	121.66	153.00	238.13	0.27	4.59
Mean of crosses	213.28	1.28	39.25	5.34	122.02	213.21	193.42	0.41	6.71
Range of crosses	171.40- 251.73	0.99- 1.65	31.90- 46.33	4.24- 5.98	118.33- 126.00	141.67- 327.17	155.93- 238.13	0.26- 0.60	4.40- 9.26
Grand mean	211.45	1.27	39.23	5.34	122.28	216.63	191.68	0.41	6.71
SE	5.06	0.08	1.29	0.14	0.97	8.05	5.32	0.02	0.35
CD at 5%	10.08	0.17	2.57	0.29	1.95	16.05	10.61	0.05	0.71
CD at 1%	13.39	0.23	3.42	0.39	2.59	21.32	14.09	0.07	0.94

Tall parents, AR-7 and AR-21 were found to record high *gca* effects and negative and positive *sca* effects with different parents. Parents with medium height recorded low and negative *gca* effects. AR-45, which was the shortest parents, showed positive but low *gca* effect but recorded highest *sca* effect in combination with another parent AR-50, which showed negative *gca* effect. Crosses which resulted in high *sca* effects were combinations of low positive x negative, low x low, low x high and high x low *gca* effects (Mohan Rao, 1994).

Parents with high *per se* performance recorded highly significant positive *gca* effects for the characters, basal stem diameter and inter-nodal length (Mohan Rao,1994). For the trait number of nodes per plant the relationship between *per se* performance and general combining ability effects appeared to be inconsistent. Parents with highest number of nodes were not found to show high *gca* effects (Padmaja, 1989).

Almost all the parents exhibited negative *gca* effects except AR-30 and AR-3, which exhibited positive *gca* effect for the character days to 50% flowering indicating that this trait is predominantly controlled by additive gene action as was also confirmed by high value of mean squares for gca. Parents with highest *per se* performance have recorded negative gca effects for fresh weight per plant. All the crosses with high x high positive gca effects gave high sca effects. This reveals that this trait is mostly governed by additive gene action which was also indicated by high value of mean squares for gca (Kumar and Palve, 1995 in jute). Four parents exhibited highly significant positive gca effects with high values of *per se* performance for the character, fibre length. The *per se* performance

Table 2 : Analysis of variance for combining ability for nine characters in roselle

Source of	d.f.	Plant height	Basal stem diameter	No.of nodes/ plant	Internodal length	Days to 50% flowering	Fresh weight/ plant	Fibre length	Fibre-wood ratio	Fibre weight/ plant
gca	7	398.31**	0.06**	15.18**	0.50**	18.66**	46.3357**	673.79**	0.0090**	4.49**
sca	28	458.98**	0.02**	13.94**	0.08**	1.21**	1959.53**	539.53**	0.0079**	1.88**
Error	70	13.33	0.00	0.82	0.01	0.45	32.65	14.66	0.0004	0.06
Additive variance		76.99	0.01	2.87	0.09	3.64	920.18	131.82	0.0017	0.88
Dominance variance		445.64	0.02	13.11	0.07	0.75	1926.88	524.86	0.0074	1.81
gca / sca		0.08	0.25	0.10	0.66	2.39	0.23	0.12	0.11	0.24

d.f. = degrees of freedom ** = significant at 1% level

Table 3 : Estimates of gca effects of eight parents for nine characters in a 8x8 diallel set in roselle

Parents	Plant height (cm)	Basal stem diameter (cm)	No.of nodes/ plant	Internodal length (cm)	Days to 50% flowering	Fresh weight/ plant (g)	Fibre length (cm)	Fibre-wood ratio	Fibre weight/ plant (g)
AR-3	-4.01**	0.04**	-2.13**	0.01	0.84**	11.68**	-11.87**	0.064**	0.78**
AR-6	3.39**	0.09**	0.13	-0.03	-0.25	30.66**	6.76**	0.015**	0.84**
AR-7	5.54**	0.04**	1.70**	0.16**	-0.89**	3.74**	7.79**	0.003	0.02
AR-13A	3.45**	-0.07**	-0.01**	-0.11**	-2.02**	-37.45**	8.24**	-0.023**	-1.16**
AR-21	5.27**	0.09**	0.70**	0.28**	-0.09**	19.81**	5.50**	-0.005**	0.40**
AR-30	-12.31**	-0.06**	-1.28**	-0.39**	2.70**	-9.62**	-10.36**	-0.006**	-0.21**
AR-45	3.07**	-0.10**	-0.11**	0.22**	-0.05**	-16.01**	-2.88**	-0.012	-0.43**
AR-50	-4.42**	-0.03	0.99**	-0.14**	-0.22**	-2.81	-3.19**	-0.035**	-0.25**
SE (gi)	1.08	0.01	0.26	0.03	0.19	1.69	1.13	0.0062	0.07

* Significant at 5% level ** Significant at 1% level

Table 4 : Estimates of sca effects of 28 crosses for nine characters in a 8 x 8 diallel set in roselle

Crossess	Plant height (cm)	Basal stem diameter (cm)	No.of nodes/ plant	Internodal length (cm)	Days to 50% flowering	Fresh weight/ plant (g)	Fibre length (cm)	Fibre-wood ratio	Fibre weight/ plant (g)
AR-3 x AR-6	21.16**	0.05	1.39	0.10	0.13	29.01**	13.25**	0.037*	0.92**
AR-3 x AR-7	-25.32**	0.00	-3.77**	0.16	-1.57**	15.43**	-30.67**	0.043*	1.44**
AR-3 x AR-13A	17.26**	0.04	3.61**	0.01	-0.77	-11.70**	17.51**	-0.035	-0.70**
AR-3 x AR-21	-20.64**	0.11**	-5.91**	0.01	0.29	2.36	-12.68**	0.131**	1.33
AR-3 x AR-30	14.90**	0.01	3.51**	-0.72**	-1.17*	-28.79**	24.01**	-0.121**	-1.35**
AR-3 x AR-45	26.51**	0.22**	2.47**	-0.21**	0.26	61.19**	15.43**	0.054**	2.07**
AR-3 x AR-50	-20.14**	0.22**	-3.89**	0.13	-0.57	13.16**	-12.52**	0.068**	1.49**
AR-6 x AR-7	23.57**	0.16**	4.22**	0.14	0.53	47.289**	20.15**	0.048**	0.85**
AR-6 x AR-13A	-13.80**	-0.14**	-1.12	-0.45**	-1.67**	-13.51**	-14.05**	-0.029	-0.90**
AR-6 x AR-21	28.64**	0.12**	4.19**	0.08	-0.93	31.55**	27.31**	0.076**	1.12**
AR-6 x AR-30	-20.33**	0.13**	-3.22**	0.23**	-1.40**	32.16**	-28.02**	0.154**	1.05**
AR-6 x AR-45	-11.85**	-0.01	0.07	0.01	-0.97	-34.61**	-2.69**	-0.040**	-0.38*
AR-6 x AR-50	-2.48**	-0.15**	-0.99	-0.07	-0.13	-63.31**	-7.92**	0.023	-1.03**
AR-7 x AR-13A	25.44**	0.12**	2.53**	-0.35**	-0.03	-41.26**	12.30**	-0.133**	-0.99**
AR-7 x AR-21	20.99**	0.23**	3.91**	-0.15	-0.30	86.87**	26.27**	0.096**	1.909**
AR-7 x AR-30	0.31	-0.09*	-0.39	0.02	1.23**	-13.91**	9.34**	-0.07**	0.11
AR-7 x AR-45	-15.20**	0.00	-2.56**	0.03	-0.67	3.97	-2.86	0.00	0.09
AR-7 x AR-50	-7.63**	-0.14**	-2.63**	-0.10	-0.83	-14.22**	-3.22	0.02	-0.97**
AR-13A x AR-21	13.68**	-0.30**	2.60**	0.11	-0.17	-51.99**	16.63**	-0.09**	-1.53**
AR-13A x AR-30	-31.19**	0.00	-4.60**	0.25**	1.69**	32.94**	-33.63**	0.03**	0.40*
AR-13A x AR-45	30.91**	0.01	5.95**	0.38**	0.13	-15.32**	40.18**	-0.08**	-0.44*
AR-13A x AR-50	-8.38**	0.04	-2.75**	-0.17	-0.70	15.30**	-14.53**	0.01	0.86**
AR-21 x AR-30	3.82	-0.08	0.30	0.73**	1.09*	-30.48**	-5.13	-0.01	-0.68**
AR-21 x AR-45	-21.50**	-0.08	-0.56	-0.17	-1.13*	-24.26**	-32.84**	-0.04**	-0.32
AR-21 x AR-50	-17.93**	-0.30**	-2.57**	-0.37**	0.03	-80.29**	-14.03**	-0.11**	-2.45**
AR-30 x AR-45	-7.48**	0.06	-5.34**	-0.08	0.39	8.01*	-20.50**	-0.02	0.42*
AR-30 x AR-50	6.48**	0.03	-0.18	0.27**	0.23	-6.51	9.13**	-0.01	-0.50**
AR-45 x AR-50	41.63**	-0.13**	6.21**	0.09	-0.33	-44.79**	52.52**	-0.09**	-1.42**
SE	3.31	0.05	0.82	0.09	0.61	5.18	3.47	0.01	0.23

* Significant at 5% level ** Significant at 1% level

of crosses had a good relationship with the sca effects similar to Padmaja (1989) in roselle.

For fibre -wood ratio, best general combiners gave both significantly positive and negative sca effects. But the *per se* performance of the crosses are in accordance with their sca effects. Hence, this trait can be selected based on the *per se* performance of crosses besides their sca effects, as predominantly non-additive gene action governs the expression of this trait (Padmaja, 1989). There seemed to be no relationship between *per se* performance and gca effects in parents for the trait fibre weight per plant. The gca of parents had no effect on their performance in crosses with other parents. Hence, selection for fibre weight per plant can be done on the basis of the *per se* performance of crosses besides their sca effects (Mohan Rao, 1994).

The results of the combining ability indicated that the choices of parents for breeding programme should be based not only on the *per se* performance and gca effects of parents but also on the sca of crosses and their *per se* performance. Parents with good individual fibre yielding ability may not be good general combiners and vice versa. In the same manner all good general combiners may not nick well with each other in their cross combinations. On the other hand parents which are poor general combiners may nick well in combination due to complimentary gene action as also reported by Anuradha and Radhakrishna (1997).

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Genetic Diversity in Redgram [*Cajanus cajan* (L.) Millsp]

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ABSTRACT

Seventy genotypes of redgram were evaluated for genetic diversity using Mahalonobis' D^2 statistic and principal component analysis. The pattern of distribution of 70 genotypes obtained from different agro-ecological regions was 9 clusters in case of D^2 analysis and 10 clusters in case of principal component analysis. Number of pods per plant contributed maximum towards genetic divergence followed by dry matter per plant and seed yield per plant. The genotypes with more number of pods and high seed yield are grouped in the cluster IX in D^2 analysis while it was cluster V in principal component analysis. The principal component analysis identified five principal components which explained 83.91% variability in redgram. The principal component analysis enabled loading of similar type of variables on a common principal component. Genotypes, JSMP-20, T-25-5-26, WRP-266 (based on PC1 axis) SM-58, Vizianagaram local -5, SM-146 (based on PC II axis), SM-30 and Amarapali-2 (based on PC III axis) were found better among the genotypes studied.

Key words : Redgram, D^2 Analysis, Principal Component Analysis

Pigeonpea is the second most important pulse crop of India. In Andhra Pradesh it is being cultivated in an area of 4.83lakh ha with 2.21 lakh tonnes of production. In any crop improvement programme, genetic diversity is an essential prerequisite for hybridization. Inclusion of diverse parents in hybridization helps in isolation of superior recombinants. Several methods for multivariate analysis such as D^2 analysis, cluster analysis, principal component analysis and metroglyph analysis have been shown to be useful in selecting genetically distant parents for hybridization. Thus, in present investigation attempt has been made to identify the extent of genetic diversity among the 70 genotypes of redgram using D^2 analysis and principal component analysis.

MATERIAL AND METHODS

The material for the investigation comprised of 70 diverse redgram genotypes (Table 1) raised in randomized block design replicated twice, during *kharif* 2004 at Regional Agricultural Research Station, Lam. Each genotype was raised in two rows of 4m length adopting inter-and intra-row spacing of 150 x 20 cm. The biometrical observations were recorded for fourteen traits *viz.*, days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, pod length, number of seeds per pod, pod yield per plant, seed yield per plant, 100 seed weight, dry matter per plant, shelling percentage, harvest index and protein content

Table 1 : List of the genotypes of redgram employed in the study

SL. No.	Genotype	SL. No.	Genotype
1	LRG-30	36	WRG-57
2	LRG-38	37	JSMP-2
3	ICPL-332	38	JSMP-8
4	ICPL-85063	39	JSMP-20
5	ICPL-87119	40	WRG-117
6	MRG-66	41	VRG-17
7	ICP-8863	42	WRG-53
8	WRG-27	43	AMARPALI-4
9	MRG-1001	44	AMARPALI-2
10	MRG-1002	45	Vizianagaram Local-1
11	MRG-1004	46	SM-7
12	WRG-53	47	SM-10
13	WRG-13	48	SM-13
14	PRG-148	49	SM-30
15	LRG-41	50	SM-31
16	WRG-150	51	SM-44
17	C-11	52	SM-58
18	ICPL-84060	53	Vizianagarm Local-5
19	ICPL86012	54	SM-102
20	JKM-161	55	SM-113
21	JKM-163	56	SM-114
22	JKM-169	57	T-25-5-26
23	GAUT-001	58	TAT-96-29
24	LRG-40	59	MAL-19
25	WRG-55	60	SM-144
26	WRP1-2	61	SM-146
27	JSMP-4	62	WRG-47
28	BSMR-736	63	CHINTAPALLI LOCAL
29	ICPL-87	64	PERINIAL-1
30	JKM-144	65	LOCAL-2002-3
31	ICPL-96058	66	LOCAL-2002-4
32	BWR-370	67	CORG-9701
33	BSMR737	68	VAMBAN-1
34	WRP-266	69	ICP-88027
35	WRG-56	70	BSMP-853

from five randomly selected plants per plot per replication. D^2 analysis (Mahalanobis, 1928) cluster analysis (Anderberg, 1993), principal component analysis (Jackson, 1991) were carried out using SPSS computer programme.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant difference among the genotypes for fourteen characters which indicated the existence of significant amount of variability among the genotypes. The 70 genotypes were grouped into 9 clusters in case of D^2 analysis (Table 2) whereas 10 in cluster analysis (Table 3 and Fig 1). The variation in the composition of individual cluster with regard to the number of genotypes indicated the presence of large amount of diversity in the population. On the basis of D^2 analysis and cluster analysis the scattering of genotypes from the same geographic region into different clusters might be due to the heterogeneity, genetic architecture of the populations, past history of selection, development traits and degree of general combining ability (Murthy and Arunachalam, 1966).

The results have clearly indicated that there is no parallelism between the geographic diversity and genetic diversity in redgram, in accordance with Katiyar *et al.* (2004). On the basis of D^2 analysis the maximum intra cluster distance was (D value) was observed in cluster VII (17.34) and it was 7.38 for cluster V while on the basis of principal component analysis the maximum intra-cluster distance was observed in cluster III (24.22) and minimum in cluster VIII (3.59).

Fig 1 : Diagram illustrat ng the clustering pattern by Ward's minimum variance method

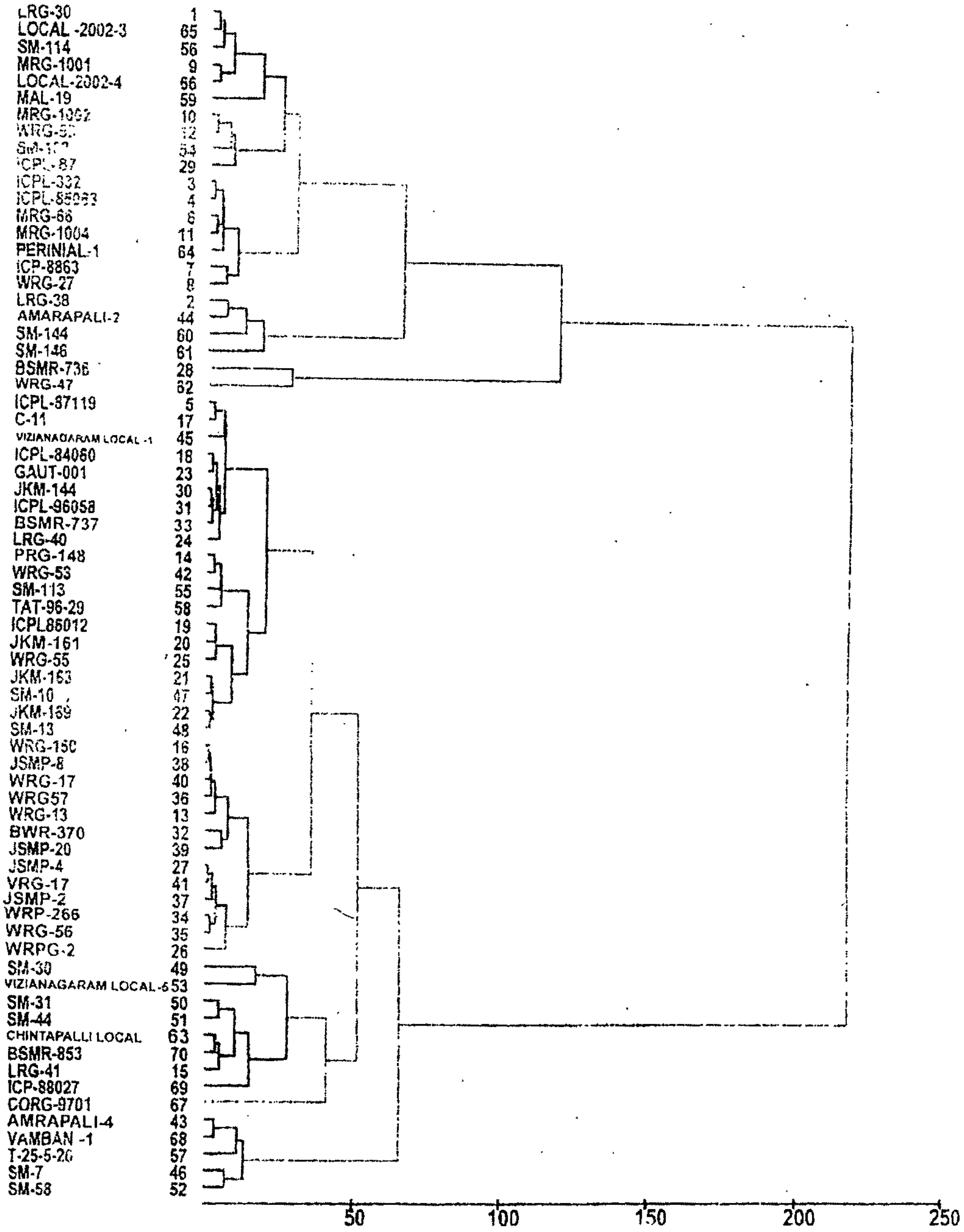


Table 2 : Distribution of 70 genotypes of redgram into different clusters as per Mahalanobis' D^2 analysis

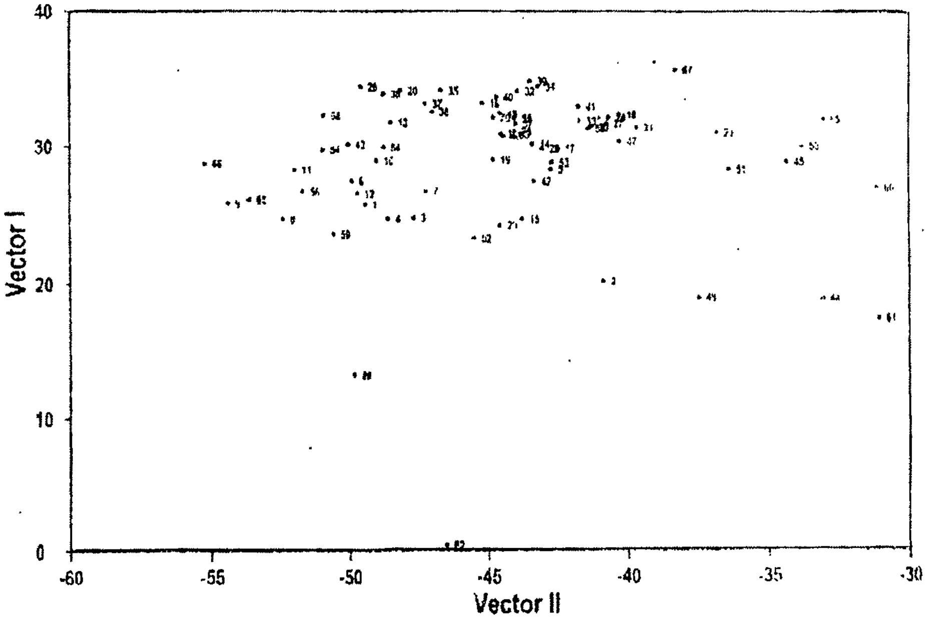
Cluster No.	Genotypes	Number of genotypes
I	LRG-30, Local-2002-03, SM-114, SM-102, Perinial-1, MRG-1001, Local-2002-04, MAL-19, MRG-1002, ICP-8863.	10
II	LRG-38, LRG-41, SM-58	3
III	ICPL-332, ICPL-85063, WRG-53, MRG-66, MRG-104, ICPL-87, WRG-27	7
IV	ICPL-87119, Chintapalli Local, BSMR-853, SM-7, JSMP-20, WRG-17, SM-31, T-25-5-26, WRG-150, JSMP-8, WRG-57, WRG-13, JKM-161, WRG-56, JSMP-2, Amrapalli-4, Vamban, WRPG-2.	18
V	PRG-148, C-11, JKM-144, ICPL-96058, BSMR-737, BWR-370, JSMP-4, VRG-17, WRP-266, ICPL-84060, LRG-40, SM-113, TAT-96-29, JKM-169, SM-13, SM-10, JKM-163, ICPL-86012, WRG-53, WRG-55	20
VI	GAU001, Viziangaram Local-1, SM-144, SM-44, Vizainagaram Local-5	5
VII	CORG-9701, ICP-88027	2
VIII	Amrapalli-2, SM-30, SM-146	3
IX	BSMR-736, WRG-47	2

Table 3 : Cluster composition of seventy (70) genotypes of redgram

Cluster No.	Number of genotypes	Genotypes
I	10	LRG-30, Local-2002-03, MRG-1001, Local-2002-4, MAL-19, MRG-1001, MRG-1002, WRG-53, SM-102, ICPL-87
II	7	ICPL-332, ICPL-85063, MRG-66, MRG-1004, PERINIAL-1, ICP83, WRG-27
III	4	LRG-38, AMRAPALI-2, SM-144, SM-146
IV	1	BSMR-736
V	1	WRG-47
VI	20	ICPL-87119, C-11, VIZIANAGARAM LOCAL-1, ICPL-84060, GAUT-001, JKM-144, ICPL-96058, BSMR-737, LRG-40, PRG-148, WRG-53, SM-113, TAT-9629, ICPL-86012, JKM-161, WRG-55, JKM-163, SM-10, JKM-169, SM-13
VII	13	WRG-150, JSMP-8, WRG-17, WRG-57, WRG-13, BWR-370, JSMP-20, JSMP-4, VRG-17, JSMP-2, WRP-266, WRG-56, WRPG-2
VIII	8	SM-30, VIZIANAGARAM LOCAL-5, SM-3, SM-44, CHINTAPALI LOCAL, BSMR-353, LRG-41, ICP-83027
IX	1	CORG-9701
X	5	AMRAPALI-4, VAMBAN-1, T-25-5-26, SM-7, SM-58

Similarly, the maximum inter-cluster distance was observed between VII and IX (1012.12) while the least being between IV and V (99.69)on the basis of D^2 analysis while it was the highest between clusters V and IX (264.66) and minimum between VI and VI (12.40) in the basis of cluster analysis (Tables 4&5).

Fig 2 : Two dimensional scattered diagram of 70 genotypes of redgram



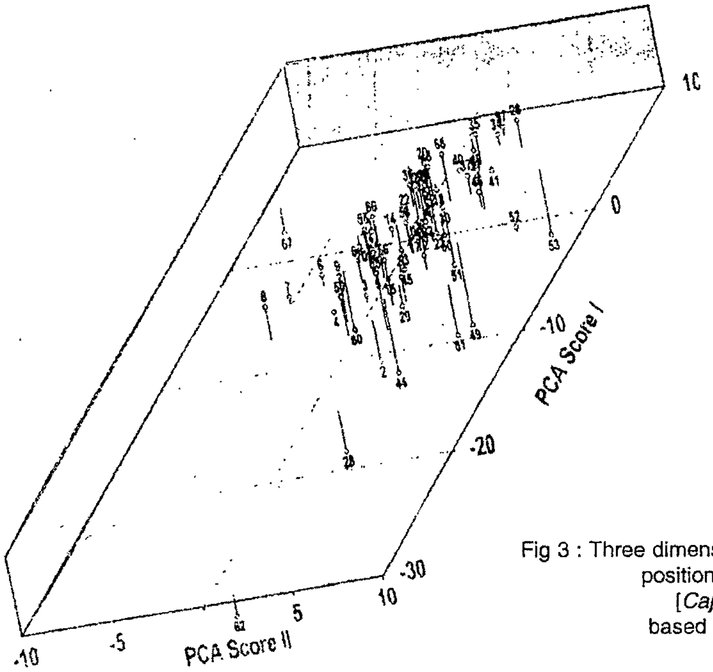


Fig 3 : Three dimensional graph showing relative position of genotypes of redgram [*Cajanus cajan* (L.) Millsp] based on PCA scores

Table 4 : Average intra-and inter-cluster distance (D) values of nine clusters

Clusters	I	II	III	IV	V	VI	VII	VIII	IX
I	**106.27** **(10.30)**	218.55 (14.78)	126.07 (11.22)	158.66 (12.59)	173.07 (13.15)	374.22 (19.34)	543.89 (23.32)	528.6 (22.99)	510.24 (22.58)
II		**115.88** **(10.76)**	156.53 (12.51)	201.85 (14.20)	189.35 (13.76)	264.83 (16.27)	417.72 (20.43)	359.62 (16.11)	388.16 (19.70)
III			**61.2** **(7.82)**	146.33 (12.09)	165.23 (12.85)	367.74 (19.17)	417.09 (20.42)	462.48 (21.50)	473.34 (21.75)
IV				**83.61** **(9.14)**	99.69 (9.98)	262.44 (16.42)	333.07 (18.25)	487.54 (22.08)	697.08 (26.40)
V					**54.60** **(7.38)**	162.35 (12.71)	287.38 (16.90)	380.80 (19.51)	165.31 (25.40)
VI						**123.64** **(11.11)**	301.47 (17.36)	308.06 (17.55)	713.14 (26.70)
VII							**300.79** **(17.34)**	555.42 (23.56)	1012.12 (31.81)
VIII								**198.59** **(14.09)**	487.05 (22.06)
IX									**267.17** **(16.36)**

Table 5 : Intra-cluster (bold) and inter-cluster Euclidean^2 values among ten clusters using Ward's minimum variance method

Cluster	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10
1	**15.96**	17.95	38.81	46.47	125.84	22.99	28.27	36.80	74.96	33.40
2		**8.54**	34.08	49.52	132.99	19.79	29.55	32.33	44.52	38.68
3			**24.22**	62.77	131.20	31.45	46.42	38.14	75.04	49.48
4				**0.00**	55.92	76.71	85.73	68.73	133.99	91.78
5					**0.00**	180.76	215.56	188.58	264.66	207.97
6						**8.99**	12.40	22.70	45.37	27.94
7							**7.88**	23.75	54.71	25.43
8								**23.40**	56.20	34.23
9									**0.00**	81.64
10										**16.94**

The additional advantage of D^2 analysis is the contribution of various characters (Table 6) towards the expression of the genetic divergence. This analysis indicated that the pods per plant (20.79), dry matter per plant (17.81), seed yield per plant (11.65), plant height (9.75) and days to maturity (7.71) contributed for more than 60 per cent of total divergence in the material, while the additional advantage in hierarchial cluster analysis (based on PCA scores) is identifying sub-cluster of the major groups at different levels so that each small group can be critically analysed.

Table 6 : Contribution of different characters towards genetic divergence

S.No.	Character	Per cent contribution towards divergence	Rank
1	Days to 50% flowering	5.22	8
2	Days to maturity	7.75	5
3	Plant height	9.75	4
4	Primary branches	4.97	9
5	Number of pods per plant	20.79	1
6	Pod length	1.32	12
7	Seeds per pod	0.48	14
8	Pod yield per plant	6.40	7
9	Seed yield per plant	11.65	3
10	100-seed weight	7.68	6
11	Drymatter per plant	17.81	2
12	Shelling percentage	0.56	13
13	Harvest index	1.79	11
14	Protein content	3.83	10

Table 7 : The eigen values, per cent variability, cumulative per cent variability for six prinicipal components

	Principal component 1	Principal component 2	Principal component 3	Principal component 4	Principal component 5	Principal component 6
Eigen value (Root)	5.72	2.37	1.97	1.40	1.10	0.76
% of variance Explained	38.15	15.86	13.73	9.39	7.36	5.10
Cumulative variance Explained	38.15	54.02	67.15	76.55	83.91	89.02

In the present investigation, principal component (PC) method was used to extract the principal factor (PF) as it does not require the assumption of normal distribution of population. The PC's with eigen values >1 were retained and <1 were considered non-significant (Legendre and Legendre, 1984). The first 3 PC's showed eigen values more than one and they together explained 83.91% of variability (Table 7). The first PC explained 38.15% of the total variability in the set of all variables and remaining ones accounted for progressively lesser and lesser amount of variation.

Principal factor scores (PF scores) for all the 70 genotypes were estimated in all the 3 PC' s and utilized to construct precise 2D plot and 3D plot (Fig 2&3). All the genotypes (names and numbers assigned are given (Table 1) were plotted for PC$_1$, PC$_2$ and PC$_3$ which cumulatively explained 83.91% variability and accounted for all the characters (Fig. 2). This plot clearly indicated the genotypes JSMP-20 (39), T-25-5-26 and WRPG-2 (26) clustering towards positive side of PC1 axis.

The genotypes Vizianagaram Local -5 (53) and SM-58 (52) stood towards positive portion of PC_2 axis while, genotypes, LRG-38 (2) and TAT-96-29 (58) found place towards better end when PC_1, PC_2 , PC_3 were considered simultaneously and are supposed to be superior for these 3 factors and hence superior for all the characters which 3 of these represented.

The plot of PC_1 PC_2 and PC_3 accounting for about 67.15% variation showed clear differentiation of genotypes according to their cluster membership for each cluster. Genotypes belonging to a common cluster have fallen nearer to each other and vice-versa there by confirming the results of cluster analysis.

Both D^2 analysis and PCA revealed a single concept of non correspondence of genetic divergence and geographic diversity. In broad sense both the methods of classifying genotypes into different groups equally useful but PCA and cluster analysis gave an additional advantage of identifying sub-clusters of the major groups at different levels so that each small group can be critically analysed.

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Genetic Divergence in Greengram (*Vigna radiata* L.)

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ABSTRACT

Genetic divergence in 40 genotypes of greengram belonging to different eco-geographical regions was studied by using Mahalanobis' D^2 statistic, cluster analysis and principal component analysis (PCA). They were grouped into 7 clusters in both D^2 analysis and cluster analysis. Clustering pattern of genotypes did not follow geographical origin in both the methods, suggesting that geographical isolation may not be the only factor causing genetic diversity. Hence, selection of parents for hybridization should be more based on genetic diversity rather than geographic diversity. Days to maturity contributed maximum towards divergence in D^2 analysis and principal component analysis identified four principal components with eigen values more than one which contributed 79.95 per cent of cumulative variance. The genotypes selected from the above analysis were MGG-295, ML-520, PDM-54, EC-19515, GG-324, GG-961 and GG-850 which appear to be desirable for inclusion in crossing programme aimed for improvement of greengram.

Key words : Greengram, Genetic Diversity, D^2 Statistic, PCA, Cluster Analysis

Greengram is the most important legume of Andhra Pradesh. In any crop improvement programme, genetic diversity is an essential pre requisite for hybridization. Inclusion of diverse parents in hybridization helps in isolation of superior recombinants. The multivariate analysis by means of Mahalanobis' D^2 statistic and principal component analysis have been shown to be useful in selecting genetically distant parents for hybridization. Thus, in present investigation, an attempt has been made to ascertain the nature and magnitude of genetic diversity to identify suitable donors having wider genetic distance in greengram.

MATERIAL AND METHODS

The material for the investigation comprised 40 genotypes of greengram (Table 1) collected from different sources, was grown in randomized block design replicated thrice, during *rabi* 2004 at Agricultural Research Station, Madhira. Each genotype was raised in three rows of 4m length with row to row and plant to plant spacing of 30 cm and 10 cm, respectively. Standard agronomic practices were adopted to raise the crop. The biometrical observations were recorded on ten competitive plants from the central rows of each plot. The characters studied were days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per cluster, pod length (cm), number of seeds per pod, 100-seed weight and seed yield per plant. D^2 analysis (Mahalanobis, 1928), principal component analysis (Jackson, 1991) and hierarchical cluster analysis (Anderberg, 1993) were carried out using SPSS computer programme.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the forty genotypes indicating the existence of substantial genetic variability for all the traits. On the bassi of D^2

Table 1 : List of greengram genotypes, their source of origin and pedigree

S.No.	Genotype	Origin	Pedigree
01	MGG-295	ARS, Madhira	PIMS-4 x C0-3
02	MGG-348	ARS, Madhira	MGG-329 x NARP-1
03	MGG-347	ARS, Madhira	K-851 x PDM-54
04	MGG-330	ARS, Madhira	PDM-84-164 x line-76
05	MGG-332	ARS, Madhira	MGG-161 x MH-309
06	MGG-341	ARS, Madhira	Local selection
07	MGG-350	ARS, Madhira	PS-16 x LGG-407
08	MGG-351	ARS, Madhira	MCG-332 x LGG-443
09	MGG-349	ARS, Madhira	MCG-329 x M-2
10	Madhiramung	ARS, Madhira	Local selection
11	LGG-410	ARS, Lam	Mutant of ML-26-10-3
12	LGG-407	ARS, Lam	Mutant of Pant M_2
13	MGG-335	ARS, Madhira	MGG-161 x LGG-407
14	LGG-450	ARS, Lam	Mutant of Pant M_2
15	LGG-460	ARS, Lam	Lam M-2 x ML-267-SB-6
16	ML-267	PAU, Ludhiana	ML-1 x LM-987
17	TM-96-2	BARC, Trombay	--
18	PDM-84-178	IIPR, Kathalgeri	--
19	PDM-11	IIPR, Kanpur	Selection from LM-595
20	BDYR	Exotic collection	--
21	Pusa bold	IARI, New Delhi	Selection from NM-92
22	GANGA-8	ARS, Sriganganagar	K-851 x PUSA-105
23	ML-520	PAU, Punjab	--
24	PDM-54	IIPR, Kanpur	Selection for germplasm collected from Kundawa Bahraich
25	EC-19515	NBPGR, New Delhi	--
26	PIMS-4	NBPGR, New Delhi	--
27	PUSA-105	IARI, New Delhi	Selection from exotic 1987 line M-178
28	ASHA	HAU, Hissar	K-851 x L 24-2
29	NM-1	PAU, Pujab	--
30	GG-851	IIPR, Kanpur	--
31	GG-850	IIPR, Kanpur	--
32	GG-324	AVRDC, Taipei	--
33	GG-329	AVRDC, Taipei	--
34	GG-26	AVRDC, Taipei	--
35	GG-338	AVRDC, Taipei	--
36	GG-545	AVRDC, Taipei	--
37	GG-961	AVRDC, Taipei	--
38	GG-500	AVRDC, Taipei	--
39	GG-436	AVRDC, Taipei	--
40	GG-804	AVRDC, Taipei	--

Fig 1 : Two dimensional graph showing relative position of genotypes of greengram [*Vigna radiata* (L.) Wilczek] based on PCA scores

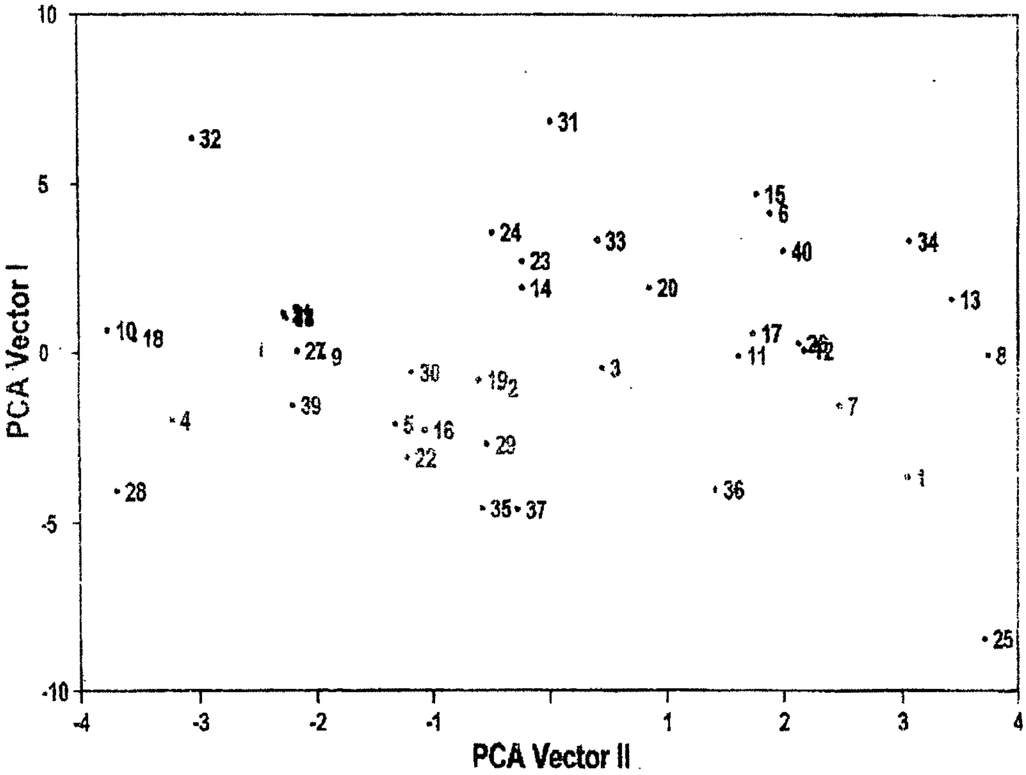


Table 2 : Clustering pattern of forty greengram [*Vigna radiata* (L.) Wilczek] genotypes based on D² statistics

Cluster	Number of genotypes	Name of the genotypes
I	19	LGG-407, PIMS-4, LGG-410, MGG-335, GG-804, MGG-351, TM-96-2, MGG-341, BDYR, LGG-460, MGG-350, PUSA-105, ML-267, PDM-11, MGG-349, GANGA-8, MGG-347, GG-851, GG-329
II	9	MGG-332,NM-1, GG-545, MGG-338, MGG-330, ASHA, Madhiramung, GG-436, GG-335
III	7	ML-520, GG-500, PDM-54, LGG-450, Pusa bold, GG-961, PDM-84-178
IV	2	GG-850, GG-26
V	1	MGG-295
VI	1	EC-19515
VII	1	GG-324

Fig 2 : Three dimensional graph showing relative position of genotypes of greengram [*Vigna radiata* (L.) Wilczek] based on PCA scores

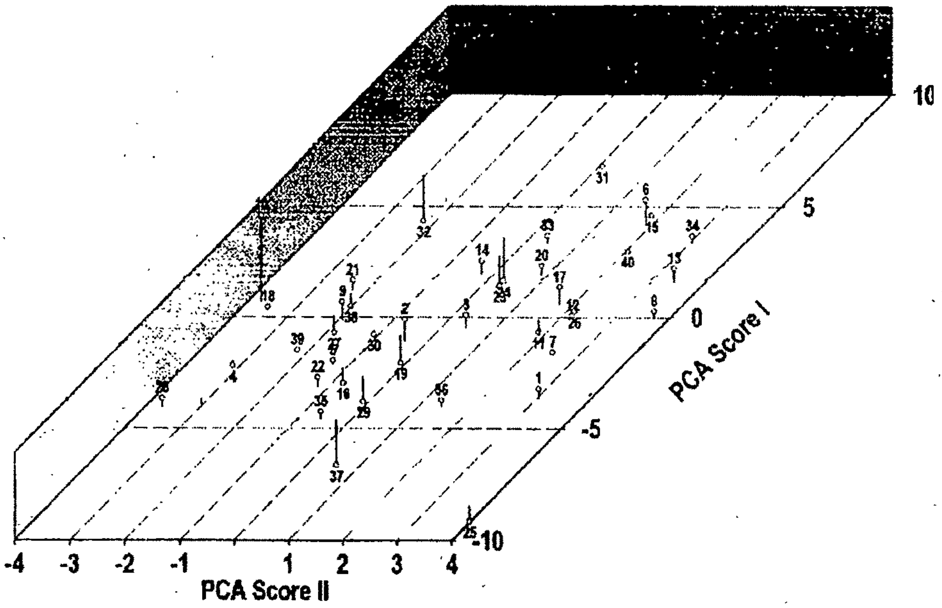


Table 3 : Mean intra (bold) and inter-cluster distances among seven clusters in greengram [*Vigna radiata* (L.) Wilczek] as per D^2 and cluster analysis

Clusters		I	II	III	IV	V	VI	VII
I	**DA**	**63.82**	118.94	148.18	203.56	164.02		361.78
	CA	**9.05**	14.57	19.31	42.85	30.47		33.79
II	**DA**		**61.37**	183.03	423.54	130.21		507.69
	CA		**8.86**	17.27	32.59	32.44		24.13
III	**DA**			**84.23**	243.59	392.84		189.59
	CA			**11.36**	37.49	46.67		59.67
IV	**DA**				**41.56**	556.02		171.16
	CA				**0.00**	83.47		61.08
V	**DA**					**0.00**		861.89
	CA					**20.33**		61.08
VI	**DA**						**0.00**	902.20
	CA						**7.59**	20.72
VII	**DA**							**0.00**
	CA							**14.35**

DA = D^2 analysis, CA = Cluster analysis

Table 4 : Cluster means for ten (10) different characters in greengram [*Vigna radiata* (L.) Wilczek]

Clusters	Days to 50% flowering	Days to maturity	Plant height (cm)	No.of primary branches/ plant	No.of clusters/ plant	No.of pods/ cluster	Pod length (cm)	No.of seeds per pod	100-seed weight (g)	Seed yield/ plant (g)
I	39.19	68.93	50.66	0.82	5.14	3.96	6.87	10.22	3.63	12.24
II	36.70	65.11	47.46	1.11	5.35	3.74	6.87	10.44	3.59	10.84
III	39.05	68.52	50.90	1.35	6.34	4.02	6.66	10.16	3.66	11.72
IV	41.00	75.67	51.60	1.10	5.30	4.07	7.23	10.43	3.52	14.48
V	37.00	65.00	48.37	0.20	3.87	4.21	6.50	9.83	3.75	11.19
VI	38.00	66.33	42.90	0.33	3.93	3.58	6.43	8.70	4.63	8.11
VII	39.33	74.00	58.90	2.07	7.00	3.88	6.40	10.63	3.78	16.05

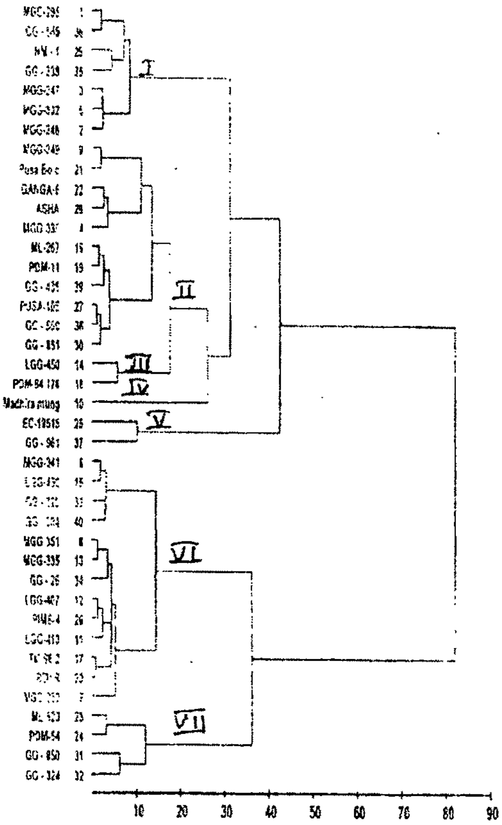
Table 5 : Character loading of four principal components for different genotypes of greengram [*Vigna radiata* (L.) Wilczek]

Character	PC 1	PC 2	PC 3	PC 4
Days to 50% flowering	0.68	0.49	0.11	0.28
Days to maturity	0.77	0.37	0.13	0.38
Plant height (cm)	0.68	-0.21	0.32	0.11
No.of primary branches / plant	0.31	-0.79	0.16	-0.01
No.of clusters / plant	0.27	-0.78	0.42	0.03
No.of pods / cluster	0.39	0.46	-0.15	-0.49
Pod length (cm)	0.22	-0.17	-0.84	0.35
No.of seeds per pod	0.52	-0.43	-0.64	0.05
100-seed weight (g)	0.81	0.18	0.16	-0.13
Seed yield / plant (g)	-0.55	0.15	0.22	0.66
Eigen value	3.16	2.17	1.57	1.07
% of variance explained	31.65	21.71	15.79	10.79
Cumulative variance explained	31.65	53.36	69.16	79.95

analysis, the 40 genotypes were grouped into 7 clusters (Table 2). The maximum number of genotypes (19) were included in cluster I. Cluster II, III had 9 and 7 genotypes, respectively and the remaining clusters had one genotype each. The pattern of distribution of genotypes into various clusters was at random suggesting that the genetic diversity was not related to geographic diversity. There are forces other than geographical separation, which are responsible for diversity such as natural and artificial selection, exchange of breeding material, genetic drift and environmental variation (Murthy and Arunachalam, 1966). Similar results were also reported by Raje and Rao (2001) Gupta *et al.* (2004) and Bhattacharya and Vijayalaxmi (2005).

Average intra-and inter-cluster D^2 values are presented in Table 3. The clustering pattern obtained in the present study revealed that there was no relation between geographic and genotypic diversity as all the genotypes included in the

Fig 3 : Diagram illustrating the clustering pattern by Ward's minimum variance method



study are from different eco-geographic regions. The inter-cluster values ranged from 66.07 to 902.20. The lowest inter-cluster value was observed between cluster V and cluster VI, which indicated that the genotypes of these two clusters were very close to each other. The highest inter-cluster value was observed between cluster VI and VII, which showed that the genotypes from these two clusters could be used as donors in hybridization programme for obtaining a wide spectrum of variation among the segregants. Cluster III recorded the highest intra-cluster distance (84.23) and it was lowest (0.00) in clusters V, VI and VII (861.89). Days to maturity (45.15%) contributed maximum towards divergence followed by number of pods per cluster (37.18%), number of primary branches per plant (9.74%) and seed yield per plant (4.23%).

The relative importance of contribution of the yield components towards divergence can be judged by comparing the group means of ten characters (Table 4). Cluster VII (GG-324) had highest mean values for maximum five characters *viz.*, plant height, primary branches per plant, clusters per plant, seeds per pod and 100-seed weight, while, cluster VI (EC-19515)

Table 6 : Cluster composition of forty (40) genotypes of greengram based on cluster analysis

Cluster	Number of genotypes	Name of the genotypes
I	7	MGG-295, GG-545, NM-1, GG-338, MGG-347, MGG-332, MGG-348
II	11	MGG-349, Pusa bold, GANGA-8, GG-851, ML-267, PDM-11, GG-436, ASHA, Pusa-105, MGG-330, GG-500
III	2	LGG-450 PDM-84-178
IV	1	Madhiramung
V	2	EC-19515, GG-961
VI	13	MGG-341, LGG-460, GG-329, LGG-410, GG-804, LGG-407, PIMS-4, TM-96-2, BDYR, MGG-351, MGG-335, MGG-350, GG-26
VII	4	GG-324, ML-520, PDM-54, GG-850

had highest value for seed yield. So, genotypes in these clusters can be used for creating variability for these yield component traits.

Principal component analysis (PCA) identified four principal components with eigen values more than one which contributed 79.95 per cent of cumulative variance. The first principal component (PC1) contributed maximum towards variability (31.65%) with significant loading of days to 50% flowering (0.684), days to maturity (0.770) and plant height (0.685) which were positively correlated and seed yield per plant (-0.552) was negatively correlated. The second principal component (PC2), which described 21.71 per cent of the total variance and it reflected significant loadings of number of primary branches per plant (-0.795) and number of clusters per plant (-0.783), which were negatively correlated. The third principal component (PC3) was characterized by conspicuously high loading of pod length (-0.844) and was negatively correlated (Table 4). The population with high PC1 values characterized by high seed yield per plant and the population with high PC2 values were characterized by high number of branches and clusters per plant.

Based on these first three principal components, mean genotype scores or PCA scores were computed. Principal factor scores (PF scores) for all the 40 genotypes were estimated in all the 3 PC' s and utilized to construct precise 2D plot and 3D plot (Fig 1&2). All the genotypes (Names and numbers assigned are given in Table 1) were plotted for PC1, PC2 and PC3 which cumulatively explained 69.16% variability and accounted for all the characters. The plot of PC1, PC2 and PC3 showed clear differentiation of genotypes according to their cluster membership for each cluster. Genotypes belonging to a common cluster have fallen nearer to each other and vice-versa. This was confirmed by cluster analysis. The mean scores of genotypes were used as input for clustering in order to group the genotypes into various clusters. Hierarchical clustering procedure (i.e. Ward' s method) was followed to group the genotypes and 40 genotypes were grouped into 7 clusters (Table 5 and 6 and Fig. 3). The distribution of genotypes into various clusters was random, indicating lack of parallelism between genetic and geographic diversity as in case of D^2 analysis.

Cluster VI was the largest comprising 13 genotypes followed by cluster II (11) and cluster I (7). The average intra and inter cluster distances (Euclidean^2 distance) are presented in Table 6. Cluster V had minimum intra cluster distance (20.33) followed by cluster VII (14.35) and cluster III (11.36). Maximum inter-cluster distance was observed between clusters IV and V (83.47) followed by clusters V and VII (61.08). Based on these studies, it could be inferred that crosses can be planned between the genotypes of these clusters to obtain better and desirable segregants. Utilization of principal component analysis combined with hierarchical cluster analysis in genetic diversity studies was reported earlier also by Altaher and Singh (2003) in cotton and Subramanian and Muthaiah (2003) in greengram and blackgarm.

In broad sense, the two methods of classifying genotypes into different groups is equally useful, but, in hierarchical cluster analysis additional advantage of identifying sub-clusters of the major groups at different levels so that each small group can be critically analyzed. Apart from the high divergence, the performance of genotypes, the characters with maximum contribution towards divergence should also be given due consideration. In this context, the characters, days to maturity and pods per cluster were the most important characters and the genotypes, MGG-295, ML-520, PDM-54, EC-19515, GG-324, GG-961 and GG-850 appear to be desirable for inclusion in crossing programme aimed for improvement of greengram.

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Character Association and Path Coefficient Analyses in Upland Cotton (*Gossypium hirsutum* L.)

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ABSTRACT

Correlation and path coefficient analyses were carried out in 80 genotypes of upland cotton that were collected from all the three cotton growing zones of India for different agronomical and fibre quality traits. The character association studies revealed that number of bolls per plant, boll weight, number of seeds per boll, lint index and seed index had significant positive association with seed cotton yield per plant. Similarly boll weight was positively correlated with number of bolls per plant, seed index and lint index. While 2.5% span length was significantly and negatively associated with maturity coefficient, uniformity ratio and micronaire. The path coefficient analysis revealed that number of bolls per plant, boll weight, number of seeds per boll, lint index, 2.5% span length and maturity coefficient exerted direct positive effect on seed cotton yield. So these traits are the prinicipal yield components and therefore, direct selection can be made for these traits to improve fibre yield in cotton.

Key words : Cotton, Character Association, Path Analysis

Seed cotton yield is a complex and quantitatively inherited character and its genetic analysis for different yield component characters shows associations among themselves and also with yield. Unfavourable associations between the desirable attributes under selection may limit genetic advances hence, knowledge of mechanisms of associations between yield and yield components and also among themselves helps in planning a sound selection programme through the selection for component traits.

MATERIAL AND METHODS

The present study was carried out with 80 genotypes of upland cotton (*Gossypium hirsutum*) obtained from different sources of all the three cotton growing zones of India. The experiment was conducted in randomized completed block design with 3 replications during *kharif* 2004-05. The inter-and intra-row spacing adopted was 120 x 60 cm. Each plot consisted of single row of 6 m length and observations were recorded on five competitive plants from each genotype per replication for 15 characters *viz.,* days to 50% flowering, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), number of seeds per boll, seed index (g), lint index (g), ginning percentage, 2.5% span length (mm), micronaire (10^{-6} g/in), maturity coefficient, uniformity ratio and bundle strength (g/tex)and seed cotton yield. The fibre quality characters were analysed at CIRCOT regional unit at RARS Lam, Guntur. The data were statistically analysed to estimate genotypic and phenotypic correlation coefficients and path coefficient relationships following the procedure of Falconer (1964) and Wright (1921), respectively.

Table 1 : Estimation of phenotypic correlation coefficient for yield and yield componets in cotton

Character	No.of monopodia /plant	No.of sympodia plant	No.of bolls/ plant	Boll weight	No.of seeds/ boll	Seed index (g)	Lint index	Ginning outturn	2.5% span length	Maturity coeffi-cient	Unifor-mity ratio	Micro-naire	Bundle strength	Seed yield/ plant
Days to 50% flowering	-0.094	0.075	-0.013	0.045	-0.157*	0.031	-0.046	-0.152	0.041	0.042	-0.191*	0.021	0.016	0.006
No.of monopodia/plant		-0.206**	0.001	-0.106	-0.030	-0.074	-0.019	0.079	0.012	-0.043	0.040	-0.077	0.073	-0.103
No.of sympodia/plant			0.113	0.010	-0.049	0.098	0.148	0.067	-0.0629	0.140	0.153	0.163*	-0.023	0.089
No.of bolls/plant				-0.339**	0.065	-0.222**	-0.236**	-0.094	-0.044	0.146	-0.048	0.176	-0.067	0.547**
Boll weight					0.274**	0.450	0.472**	0.037	0.037	0.042	0.046	-0.019	0.021	0.503**
No.of seeds/boll						-0.063	-0.026	0.115	0.102	-0.107	-0.101	-0.171*	0.067	0.272**
Seed index							0.730**	-0.262**	0.261**	0.052	-0.084	0.012	0.074	0.178*
Lint index								0.281**	0.109	0.104	0.090	0.117	-0.030	0.193*
Ginning outturn									-0.134	0.014	0.206**	0.064	-0.141	-0.072
2.5% Span length										-0.228**	-0.529**	-0.327**	0.268**	0.031
Maturity coefficient											0.371**	0.776**	0.134	0.128
Uniformity ratio												0.373**	-0.036	-0.007
Micronaire													-0.415**	0.122
Bundle strength														-0.066

* Significant at 5% level **Significant at 1% level

RESULTS AND DISCUSSION

The seed cotton yield per plant exhibited (Table 1 and 2) positive genotypic correlation with number of bolls per plant, boll weight, number of seeds per boll, lint index and seed index in conformity with Neelam and Potdukhe (2002), Altaher and Singh (2003), Gururajan and Sundar, (2004), while Rao *et al.* (2001) noticed that bundle strength had negative association with seed cotton yield per plant. Boll weight was significantly and positively associated with number of seeds per boll, seed index and lint index in accordance with Altaher and Singh (2003) and Gururajan and Sundar (2004). Seed index showed positive association with lint index and 2.5% span length, while it was negatively and significantly associated with ginning outturn in agreement with the reports of Neelam and Potdukhe (2002) and Muthu *et al.* (2004).

Seed index was positively and significantly associated with lint index and 2.5% span length while, it was significantly and negatively correlated with ginning outturn in agreement with Gururajan and Sundar (2004) and Muthu *et al.* (2004). 2.5% span length showed significant negative association with maturity coefficient and uniformity ratio and micronaire in agreement with Altaher and Singh (2003) and Muthuswamy and Vivekanandan (2004).

Number of bolls per plant, boll weight, number of seeds per plant, seed index and lint index had strong association with seed cotton yield per plant and hence maximum emphasis should be given for these characters to increase the seed cotton yield per plant. Boll weight, number of seeds per boll, seed index, lint index and boll weight, number of seeds per boll, seed index, lint index and 2.5% span length, maturity coefficient, uniformity ratio and micronaire were interrelated among themselves and would bring in simultaneous improvement in addition to seed

Table 2 : Estimation of genotypic correlation coefficient for yield and yield componets in cotton

Character	No.of monopodia/ plant	No.of sympodia plant	No.of bolls/ plant	Boll weight	No.of seeds/ boll	Seed index (g)	Lint index	Ginning outturn	2.5% span length	Maturity coeffi- cient	Unifor- mity ratio	Micro- naire	Bundle strength	Seed yield/ plant
Days to 50% flowering	0.194*	-0.649**	-0.105	-0:314**	0.520**	0.183*	0.266**	0.553*	0.092	0.007	-0.060	0.206	-0.375**	-0.062
No.of monopodia/plant		-0.191	0.088	-0.136	-0.072	-0.058	-0.019	0.269**	0.030	-0.007	0.121	-0.073	0.048	-0.070
No.of sympodia/plant			-0.005	0.088	-0.088	0.122	0.165*	0.018	-0.076	0.158*	0.186*	0.156*	0.087	0.041
No.of bolls/plant				-0.409**	0.118	-0.407	-0.468**	-0.335**	-0.064	0.249*	0.040	0.259**	-0.073	0.527*
Boll weight					0.350**	0.517**	0.580**	0.202*	-0.024	0.158*	0.034	0.014	0.013	0.544**
No.of seeds/boll						-0.030	0.057	0.192*	0.190*	-0.319**	-0.276**	-0.214**	-0.053	0.424**
Seed index							0.741**	-0.332**	0.274**	0.058	-0.086	-0.053	0.117	0.146
Lint index								0.340**	0.130	0.212**	0.134	0.102	-0.012	0.191*
Ginning outturn									-0.0134	-0.306**	0.245**	-0.034	-0.342**	-0.068
2.5% Span length										-0.520**	-0.818**	-0.501**	0.319**	-0.017
Maturity coefficient											0.527**	0.818**	-0;218**	0.378**
Uniformity ratio												0.470**	-0.290**	0.004
Micronaire													-0.721**	0.318**
Bundle strength														-0.090

* Significant at 5% level **Significant at 1% level

cotton yield. Micronaire was significantly and positively associated with maturity coefficient as reported by Neelam and Potdukhe (2002) and Altaher and Singh (2003).

The path analysis (Table 3 and 4) indicated that number of bolls per plant, boll weight, number of seeds per boll, lint index, 2.5% span length and maturity coefficient exerted direct positive effect on seed cotton yield in complete agreement with Altaher and Singh (2003) and Muthu *et al.* (2004) and for these traits direct selection can be made to improve the yield. Number of bolls per plant had positive and greater indirect effect on yield *via.*, number of seeds per boll, seed index, ginning outturn and maturity coefficient hence selection through these characters may bring about improvement in seed cotton yield in agreement with Gururajan and Sundar (2004) and Muthu *et al.* (2004).

Boll weight exhibited positive indirect effect on yield through number of monopodia per plant, number of seeds per boll, lint index, 2.5% span length, maturity coefficient, uniformity ratio and micronaire similar to Gururajan and Sundar (2004) and Muthu *et al.* (2004).

Lint index had positive indirect effect on yield *via.*, days to 50% flowering, number of monopodia per plant, boll weight, 2.5% span length, maturity coefficient and uniformity ratio. While it has negative indirect effect due to number of bolls per plant in accordance with Altaher and Singh (2003) and Gururajan and Sundar (2004). The trait, 2.5% span length had positive indirect effect through number of sympodia per plant, boll weight, number of seeds per boll and lint index as reported by Muthu *et al.* (2004).

Seed cotton yield can be improved through number of bolls per plant, boll weight, number of seeds per boll, lint index, seed index and these characters showed positive association with two

Table 3 : Estimation of direct and indirect effects (phenotypic) between yield and yield components in 80 genotypes

Character	Days to 50% flowering	No.of monopodia /plant	No.of sympo-dia/plant	No.of bolls/ plant	Boll weight	No.of seeds/ boll	Seed index	Lint index	Ginning out-turn	2.5% span length	Maturity coeffi-cient	Unifor-mity ratio	Micro-naire	Budle strength	Correlation with seed yield/plant
Days to 50% flowering	**-0.0170**	0.0016	-0.0013	0.0002	-0.0008	0.0027	-0.0005	0.0008	0.0026	-0.0007	0.0007	0.0032	-0.0004	-0.0003	0.0006
No.of monopodia/plant	0.0024	**-0.0260**	0.0054	0.000	0.0028	0.0008	0.0019	0.0005	-0.0021	-0.0003	0.0011	-0.0010	0.0020	-0.0019	-0.103
No.of sympodia/plant	-0.0010	0.0027	**-0.0131**	-0.0015	-0.0001	0.0006	-0.0013	-0.0019	-0.0009	0.0008	-0.0018	-0.0020	-0.0021	0.0003	0.089
No.of bolls/plant	-0.0105	0.0011	0.0910	**0.8081**	-0.2739	0.0527	-0.1792	-0.1912	-0.0762	-0.0353	0.1180	-0.0392	0.1425	-0.0545	0.547**
Boll weight	0.0347	-0.0811	0.0077	-0.2856	**0.7630**	0.2092	0.3436	0.3599	0.0284	0.0282	0.0323	0.0348	-0.0145	0.0163	0.503**
No.of seeds/boll	-0.0014	-0.0003	-0.0005	0.0006	0.0025	**0.0092**	-0.0006	-0.0002	0.0011	0.0009	-0.0010	-0.0009	-0.0016	0.0006	0.272**
Seed index	-0.0034	0.0081	-0.0106	0.0242	-0.0491	0.0065	**-0.1089**	-0.0795	0.0286	-0.0285	-0.0057	0.0092	-0.0013	-0.0081	0.178*
Lint index	-0.0056	-0.0023	0.0178	-0.0286	0.0570	-0.0032	0.0881	**0.1208**	0.0340	0.0131	0.0125	-0.0192	0.0141	-0.0037	0.193*
Ginning outturn	0.0142	-0.0074	-0.0063	0.0088	-0.0035	-0.0107	0.0245	-0.0263	**-0.0933**	0.0126	-0.0013	0.0109	-0.0060	0.0132	-0.072
2.5% Span length	0.0029	0.0008	-0.0044	-0.0031	0.0026	0.0071	0.0183	0.0076	-0.0094	**0.0702**	-0.0160	-0.0371	-0.0229	0.0188	0.031
Maturity coefficient	0.0009	-0.0010	0.0031	0.0033	0.0009	-0.0024	0.0012	0.0023	0.0003	-0.0051	**0.0224**	0.0083	0.0174	0.0030	0.128
Uniformity ratio	-0.0080	-0.0017	0.0065	-0.0020	0.0019	-0.0043	-0.0036	0.0038	0.0087	-0.0223	0.0157	**0.0422**	0.0158	-0.0015	-0.007
Micronaire	-0.0010	0.0038	-0.0080	-0.0087	0.0009	0.0084	-0.0006	-0.0057	-0.0032	0.0161	-0.0382	-0.0184	**-0.0492**	0.0204	0.122
Bundle strength	0.0011	-0.0051	0.0016	0.0047	-0.0015	-0.0047	-0.0054	0.0027	0.0098	-0.0185	-0.0092	0.0025	0.0287	**-0.0691**	-0.066

* Significant at 5% level **Significant at 1% level Residual effect = 0.3949 Bold and underlined figures are direct effects

Table 4 : Estimation of direct and indirect effects (genotypic) between yield and yield components in 80 genotypes

Character	Days to 50% flowering	No.of monopodia/ plant	No.of sympo-dia/plant	No.of bolls/ plant	Boll weight	No.of seeds/ boll	Seed index	Lint index	Ginning out-turn	2.5% span length	Maturity coeffi-cient	Unifor-mity ratio	Micro-naire	Budle strength	Correlation with seed yield/plant
Days to 50% flowering	**0.3808**	0.00738	-0.2472	-0.399	-0.1196	0.1981	0.0698	0.1014	0.2107	0.0349	0.0025	-0.0230	0.0783	-0.1428	-0.0620
No.of monopodia/plant	0.0536	**-0.2768**	0.0529	-0.0244	0.0378	0.0198	0.0160	0.0053	-0.0744	-0.0084	0.0020	-0.0335	0.0202	-0.0133	-0.0705
No.of sympodia/plant	0.0973	0.0287	**-0.1500**	0.0008	-0.0133	0.0133	-0.0183	-0.0247	-0.0027	0.0113	-0.0237	-0.0280	-0.0233	-0.0130	0.0406
No.of bolls/plant	-0.1296	0.1088	-0.0065	**1.2356**	-0.5057	0.1457	-0.5023	-0.5780	-0.4136	-0.0797	0.3080	-0.0489	0.3197	-0.0898	0.5272
Boll weight	-0.4220	-0.1835	0.1189	-0.5501	**1.3440**	0.4710	0.6944	0.7794	0.2719	-0.0330	0.2124	0.0457	0.0191	0.0173	0.5436
No.of. seeds/boll	-0.1850	0.0255	0.0315	-0.0419	-0.1246	**-0.3557**	0.0106	-0.0203	-0.0681	-0.0675	0.1135	0.0983	0.0760	0.0190	0.4242
Seed index	0.1610	-0.0507	0.1069	-0.3573	0.4541	-0.0261	**0.8788**	0.6510	-0.2916	0.2408	0.0513	-0.0761	-0.0464	0.1030	0.1457
Lint index	-0.2675	0.0192	-0.1656	0.4702	-0.5829	-0.0573	-0.7446	**-1.0052**	-0.3414	-0.1307	-0.2132	-0.1348	-0.1029	0.0196	0.1913
Ginning outturn	0.5039	0.2447	0.0167	-0.3049	0.1842	0.1745	-0.3022	0.3093	**0.9106**	-0.1262	-0.2783	0.2227	-0.0311	-0.3112	-0.0677
2.5% Span length	0.0142	0.0047	-0.0117	-0.0100	-0.0038	0.0294	0.0425	0.0201	-0.0215	**0.1550**	-0.0806	-0.1267	-0.0777	0.0495	-0.0173
Maturity coefficient	-0.0075	0.0081	-0.1784	-0.2814	-0.1785	0.3604	-0.0660	-0.2394	0.3450	0.5874	**-1.1290**	-0.5945	-0.9232	0.2462	0.3776
Uniformity ratio	-0.0032	0.0063	0.0097	-0.0021	0.0018	-0.0145	-0.0045	0.0070	0.0128	-0.0428	0.0275	**0.0523**	0.0246	-0.0114	0.0037
Micronaire	0.4340	-0.1539	0.3282	0.5460	0.0300	-0.4510	-0.1114	0.2159	-0.0720	-1.0572	1.7253	0.9915	**2.1099**	-1.5222	0.3178
Bundle strength	-0.5848	0.0748	0.1351	-0.1134	0.0201	-0.0834	0.1829	-0.0304	-0.5332	0.4984	-0.3402	-0.3416	-1.1255	**1.5601**	-0.0889

Residual effect = SQRT (1-1;1981) Bold and underlined figures are direct effects or three fibre quality parameters like maturity coefficient, micronaire and ginning outturn. Maturity coefficient and uniformity ratio showed negative association with 2.5% span length. Thus major emphasis should be laid on selection process with high number of bolls per plant, high boll weight, lint index and seed index for better genotypes with superior fibre quality and for realizing higher seed cotton yield.

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Management of Tobacco Caterpillar *Spodoptera litura* (F.) and Ragi Cutworm *Spodoptera exigua* (Hb.) on Onion

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ABSTRACT

The study on the management of *Spodoptera litura* and *Spodoptera exigua* on onion was conducted during *rabi*, 2003-04 in Yarrabalem Village of Guntur District, employing 13 treatments including control. Treatments were given twice during the cropping season. Among the treatments spinosad 0.015% spray was the most effective against target pests which recorded larval reduction to an extent 78 to 79% over untreated check followed by Indoxacarb 0.0145% by recording the larval reduction of 71% over control.

Key words : Tobacco Caterpillar, Ragi Cutworm, Onion

Onion is one of the important vegetable crops grown in India. Important pests recorded on onion are thrips (*Thrips tabaci* L.) dipteran fly (*Hylemia antique* M.); lucerne caterpillar (*Spodoptera exigua* Hb.); tobacco caterpillar (*Spodoptera litura* F.) and head borer (*Helicoverpa armigera* H.) (Saha, 1990). Of late tobacco caterpillar, *S. litura* and Lucerne caterpillar *S. exigua* have been observed to cause more economical damage to *rabi* onion around Mangalagiri, Guntur District. Infestation of these pests during initial stages of the crop growth (30-40 days after planting) generally results in extensive defoliation of the crop necessitating replanting otherwise it results in drastic reduction in the yield because of the poor development of bulbs at later stages of the crop growth.

Farmers are applying various insecticides of their own choice to combat the pest menace, which leads to toxic hazards to consumers by the residues especially, when the bulbs are used as raw and also in situations where the entire plant along with the foliage is consumed during the vegetative phase of the crop. Hence, it is felt necessary to manage the pests with ecofriendly and safer chemicals like neem products and biopesticides. Keeping these points in view, the present investigation was carried out.

MATERIAL AND METHODS

Field experiment was laid out during *rabi* 2003-04 in RBD with 8 m^2 plot size to evaluate the efficacy of different insecticides against *Spodoptera litura* and *Spodoptera exigua* on onion. Neem oil, bacterial formulation, NPV, entomophagous fungi, chitin inhibitors and some of the new molecules were evaluated with the recommended concentrations against the incidence of the pests. Different insecticidal foliar sprays were given after the infestation of the target pest reached two larvae per plant and the second spray was given 15 days later.

The larval population was recorded at one, five, ten and fifteen days after each insecticidal

Table 1 : Overall efficacy of different treatments (mean of two sprays) against *S. litura* on onion during *rabi* 2003-2004

	Treatments	Pretreatment Mean larval population/10 plants	Mean per cent reduction of larvae over control at				
			1 DAS	5 DAS	10 DAS	15 DAS	Mean efficacy
T_1	Neemoil 0.5%	15.16	21.16 (27.38)^{i}	41.16 (39.90)^{i}	59.40 (50.42)^{k}	53.07 (46.76)^{g}	43.69 (41.11)^{h}
T_2	*B.t.* 1kg/ha	14.32	25.75 (30.49)^{f}	49.81 (44.89)^{i}	74.43 (59.62)^{e}	70.72 (57.24)^{c}	55.17 (48.06)^{ef}
T_3	NPV 300 LE/ha	13.91	23.99 (29.32)^{g}	48.30 (44.02)^{g}	76.67 (61.11)^{c}	69.03 (56.18)^{d}	54.49 (47.65)^{f}
T_4	*B.t.* 0.5 kg/ha + NPV 150 LE/ha	12.59	28.68 (32.38)^{e}	53.03 (46.74)^{e}	78.58 (62.43)^{b}	73.52 (59.03)^{b}	58.45 (50.14)^{de}
T_5	Spinosad 0.015%	10.42	50.11 (45.06)^{d}	80.18 (63.56)^{b}	95.22 (77.38)^{a}	88.94 (70.57)^{a}	78.67 (64.14)^{a}
T_6	*Beauveria bassiana* (1x10^{8} spores/ml)	16.62	22.47 (28.29)^{h}	45.99 (42.70)^{h}	70.98 (57.48)^{g}	55.66 (48.25)^{f}	48.77 (44.18)^{g}
T_7	*Nomuraea rileyi* (1x10^{8} spores/ml)	16.72	22.48 (28.30)^{h}	41.92 (40.35)^{i}	68.96 (56.14)^{i}	58.88 (50.11)^{e}	48.06 (43.72)^{g}
T_8	Indoxacarb 0.0145%	17.12	73.59 (59.07)^{a}	84.10 (66.50)^{a}	75.03 (60.02)^{de}	51.96 (46.12)^{h}	71.17 (57.92)^{b}
T_9	Navaluron 0.01%	13.02	25.10 (30.05)^{fg}	52.21 (46.26)^{e}	70.30 (56.98)^{h}	70.36 (57.01)^{c}	54.49 (47.57)^{f}
T_{10}	Lufenuron 0.01%	11.77	25.48 (30.31)^{f}	48.08 (43.90)^{g}	72.04 (58.07)^{g}	71.04 (57.44)^{c}	54.16 (47.43)^{f}
T_{11}	Lambda cyhalothrin 0.01%	14.88	65.89 (54.26)^{b}	73.61 (59.09)^{c}	75.50 (60.33)^{d}	48.18 (43.96)^{i}	65.79 (54.41)^{c}
T_{12}	Chlorpyriphos 0.05%	16.11	58.39 (49.83)^{c}	71.15 (57.51)^{d}	63.41 (52.78)^{i}	49.49 (44.71)^{i}	60.61 (51.20)^{d}
T_{13}	Control	26.83	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	F test	NS	Sig	Sig	Sig	Sig	Sig
	SE D		0.37	0.27	0.26	0.26	1.38
	CD (P=0.05)		0.77	0.58	0.56	0.53	2.85

Figures in parantheses are angular transformed values.
Sig - significant, DAS - Days after spraying
Number followed by same letter in each column are not significantly different.

spray apart from pretreatment counts. Larval population was recorded by distructive sampling of ten plants selected at random in each plot.

RESULTS AND DISCUSSION

The overall mean efficacy of the insecticides recorded at 1,5,10 and 15 days after treatments after two sprayings against *S. litura* indicated the superiority of spinosad 0.015 per cent over the rest of treatments which recorded the larval reduction of 78.61 per cent (Table 1). The next best chemical was indoxacarb 0.0145% (71.17%) followed by lambda cyhalothrin 0.01

Table 2 : Overall efficacy of different treatments (mean of two sprays) against *S. exigua* on onion during *rabi* 2003-2004

	Treatments	Pretreatment Mean larval population/10 plants	Mean per cent reduction of larvae over control at 1 DAS	5 DAS	10 DAS	15 DAS	Mean efficacy
T_1	Neemoil 0.5%	6.96	22.56 (28.36)^{h}	42.84 (40.88)^{h}	62.01 (51.95)^{h}	52.74 (46.57)^{h}	45.03 (41.94)^{i}
T_2	*B.t.* 1kg/ha	5.08	27.36 (31.53)^{f}	50.02 (45.01)^{ef}	77.19 (61.47)^{d}	71.92 (58.00)^{c}	56.62 (49.00)^{de}
T_3	NPV 300 LE/ha	5.23	26.82 (31.18)^{f}	48.38 (44.07)^{fg}	81.74 (64.70)^{b}	70.75 (57.26)^{e}	56.92 (49.30)^{d}
T_4	*B.t.* 0.5 kg/ha + NPV 150 LE/ha	4.60	28.99 (32.57)^{e}	54.43 (47.54)^{de}	79.25 (62.90)^{c}	76.75 (61.17)^{b}	59.85 (51.04)^{de}
T_5	Spinosad 0.015%	4.87	49.86 (44.92)^{d}	81.66 (64.64)^{b}	97.15 (80.28)^{a}	90.67 (72.21)^{a}	79.83 (65.51)^{a}
T_6	*Beauveria bassiana* (1x10^{8} spores/ml)	5.39	23.94 (29.29)^{g}	47.27 (42.28)^{gh}	73.01 (58.70)^{e}	57.57 (49.35)^{h}	49.94 (44.90)^{f}
T_7	*Nomuraea rileyi* (1x10^{8} spores/ml)	5.69	23.70 (29.13)^{g}	44.54 (41.86)^{gh}	70.66 (56.82)^{f}	62.52 (52.25)^{g}	50.20 (45.01)^{f}
T_8	Indoxacarb 0.0145%	5.80	75.22 (60.14)^{a}	86.02 (68.05)^{a}	77.21 (61.48)^{d}	55.83 (48.34)^{i}	73.57 (59.50)^{b}
T_9	Navaluron 0.01%	5.70	27.03 (31.33)^{f}	58.44 (49.92)^{d}	73.40 (58.95)^{e}	71.80 (57.92)^{d}	57.66 (49.53)^{de}
T_{10}	Lufenuron 0.01%	5.30	28.61 (32.34)^{e}	49.36 (44.63)^{f}	77.00 (61.34)^{b}	70.24 (56.94)^{f}	56.30 (48.81)^{e}
T_{11}	Lambda cyhalothrin 0.01%	6.38	70.25 (56.94)^{b}	76.37 (60.91)^{c}	69.96 (56.76)^{f}	54.19 (47.40)^{j}	67.69 (55.50)^{c}
T_{12}	Chlorpyriphos 0.05%	6.27	59.93 (50.49)^{c}	74.85 (59.91)^{c}	65.26 (53.88)^{g}	52.57 (46.47)^{k}	63.05 (52.68)^{cd}
T_{13}	Control	18.18	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	F test	NS	Sig	Sig	Sig	Sig	Sig
	SE D		0.23	1.23	0.14	0.12	1.82
	CD (P=0.05)		0.50	2.54	0.30	0.23	3.76

Figures in parantheses are angular transformed values.
Sig - significant, DAS - Days after spraying
Number followed by same letter in each column are not significantly different.

per cent (65.79%). The efficacy of chloropyriphos 0.05 per cent, *B.t.* 0.5 kg/ha + NPV 150 LE/ha and *B.t.* 1 kg/ha was found to be intermediary which recorded 60.61, 58.45 and 55.17 per cent reduction, respectively. Treatments *viz.,* NPV 300 LE/ha (54.49%), novaluron 0.01% (54.49%) and lufenuron 0.01% (54.16%) which were on par with one another, exhibited moderate toxicity. Next in the order of efficacy were *Beauveria bassiana* 1 x 10^{8} spores/ml (48.77%), N. rileyi 1 x 10^{8} spores/ml (48.06%) and neemoil 0.5% (43.69%) which were observed to be less effective.

The overall mean efficacy of the treatments against *S. exigua* recorded after two sprayings indicated that spinosad 0.015 per cent remained as effective insecticide with a larval reduction of 79.83 per cent followed by indoxacarb 0.0145 per cent which registered a larval reduction of 73.57 per cent (Table 2). Lambda cyhalothrin 0.01 per cent and chloropyriphos 0.05 per cent which were on par with each other were found to be the next best treatments with 67.69 and 63.05 per cent larval reduction, respectively. The efficacy of the *B.t.* 0.5 kg + NPV 150 LE/ha (59.85%), novaluron 0.01 per cent (57.66%), NPV 300 LE/ha (56.92%) *B.t.* 1 kg/ha (56.62%) and lufenuron 0.01 per cent (56.30%) were intermediary and equally effective. The remaining treatments in the descending order of toxicity were *Nomuraea rileyi* 1 x 10^8 spores/ml (50.20%) *B. bassiana* 1 x 10^8 spores/ml (49.94%) and neem oil 0.5 per cent (45.03%) which were on par with one another and least effective.

The overall mean efficacy of the insecticides recorded at 1,5,10 and 15 DAT during the period of two sprayings clearly revealed the superiority of spinosad 0.015 per cent over other treatments which offered a larval reduction of 78.61 and 79.83 per cent over untreated control with respect of *S. litura* and *S. exigua,* respectively. This is in agreement with the findings of Ahmed *et al.* (2001) and Mascarenhas *et al.* (1998). The next best treatment after spinosad 0.015 per cent was indoxacarb 0.0145 per cent which resulted in the mean reduction of larval population to an extent of 71.17 per cent in *S. litura* and 73.57 per cent in *S. exigua.* This result is in agreement with the findings of Papa *et al.* (1999). Lambdacyhalothrin 0.01 per cent was another effective insecticides after indoxacarb 0.0145% with a larval reduction of 65.79 and 67.69% over control in *S. litura* and *S. exigua* respectively similar to the reports of Patil and Shekarappa (2000).

The other treatment which recorded high degree of efficacy was chlorpyriphos 0.05 per cent with a larval reduction of 60.61 per cent in *S. litura* and 63.05 per cent in *S. exigua*. These findings are in confirmation with the findings of Patel and Chari (1980) and Senapathi and Ghosh, (1992). In the present findings *B.t.* 0.5 kg ha^{-1} + NPV 150 Le ha^{-1} was intermediary in its efficacy with a larval reduction of 58.45 and 59.85% in *S. litura* and *S. exigua.* This is in agreement with Padua *et al.* (1999). The other treatments which recorded moderate degree of efficacy were *B.t.* 1 kg ha^{-1}, NPV 300 LE ha^{-1}, novaluron 0.01%, lufenuron 0.01% with a larval reduction ranging from 54.16 to 57.66. The efficacy of *B.t.* on *S. litura* in present findings is quite contrary to the findings of Narayanan *et al.* (1970) who reported that *S. litura* was susceptible to *B.t.* to the extent of 100% larval mortality at six days after treatment.

In the present study, entomophagous fungi *viz., B. bassiana* and *N. rileyi* showed less efficacy with larval reduction ranging from 48.6 to 50.00 per cent in conformation with the findings of Dayakar and Kanauzia (2001).

Neemoil 0.5% showed poor efficacy with a larval reduction of 43.69 and 15.03 per cent against *S. litura* and *S. exigua.* This result is in agreement with findings of Ramesh babu and Krishnaiah (1998), who reported the inferior efficacy of neemoil against *S. litura.*

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Comparative Efficacy of Selected Insecticides Against Shoot and Fruit Borer on Brinjal

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ABSTRACT

Novel insecticides like Dimilin, Bactospeine, Repelin were used alone at the recommended doses and in combination with conventionals like fenpropathrin, monocrotophos and carbaryl at half the recommended concentrations against shoot and fruit borer of brinjal. During the crop period three sprays were given and observations were recorded on the incidence of fruit borer and also yield. Among all the treatments tested, diflubenzuron + fenpropathrin was the most effective in controlling the borer as well as recording higher yields over control (77.69%) followed by bactospeine + fenpropathrin (73.14%).

Key words : Conventionals, Novel Insecticides, Efficacy, Borer Incidence, Yield

Brinjal is an important solanaceous vegetable grown widely all over the country. It is high in nutritive value with 6.4% carbohydrates, 1.3% fat, 0.02% calcium, 0.06% phosphorus and is also claimed to have medicinal value. As many as 26 species of insect and non-insect pests have been reported to attack and cause damage to brinjal crop (Vevai, 1970). Among them fruit borer, (*Leucinodes orbonalis* Guen), is one.

Due to the irrational use of conventional insecticides several adverse effects like pest resistance, resurgence, residues, environmental pollution etc., cropped up. To overcome the above disadvantages novel methods of pest control should be utilized. New insecticides like diflubenzuron (Dimilin 25 WP) a chitin inhibitor, *Bacillus thuringiensis* 16000 IU/mg (Bactospeine) a microbial insecticide and Neem product (RD-9 Repelin 100EC) were utilized alone and in combination with conventional insecticides like fenpropathrin (Danitol 10 EC), monocrotophos (Nuvacron 36 SC) and carbaryl (Sevin 50 WP) at half of the recommended dosage to control the fruit borer on brinjal.

MATERIAL AND METHODS

Pusa Purple Long variety of brinjal seed weighing 150 gm was raised in a nursery seedbed of 3 m^2 area during 1990 in the college farm, College of Agriculture, Rajendranagar. The field seedlings at experiment was laid out in randomised block design with 16 treatments replicated thrice. The plots measuring 20 m^2 each were transplanted with brinjal seedlings at inter- and intra-row spacing of 75 x 50 cm. The recommended agronomic practices were carried out from time to time.

The insecticides were sprayed with knapsack compression sprayer at fortnightly intervals. A total of three sprayings were given during the crop season for protection against the pest complex of brinjal. Harvesting was carried out in eight pickings. Fruits harvested at each picking were counted separately, treatment-wise. The fruits were categorized into healthy and bored fruits. Their number and weight was recorded separately. The per cent increase in yield over the yield of control plot was calculated

Table 1 : Efficacy of treatments against fruit brorer (*Leucinodes orbonalis* L.) in brinjal

S.No.	Treatment	Dose	Mean%damage
1	Diflubenzuron	0.025	7.85 (16.27)
2	Bactospeine	0.15	10.20 (18.65)
3	Fenpropathrin	0.02	3.88 (11.36)
4	Monocrotophos	0.054	5.85 (14.00)
5	Carbaryl	0.15	7.35 (15.73)
6	Repelin	1.00	9.19 (17.65)
7	Diflubenzuron+bactospeine	0.0125 + 0.075	8.37 (16.82)
8	Diflubenzuron+fenpropathrin	0.0125 + 0.01	3.38 (10.59)
9	Diflubenzuron+monocrotophos	0.0125 + 0.027	4.58 (12.36)
10	Diflubenzuron+carbaryl	0.0125 + 0.075	6.09 (14.29)
11	Diflubenzuron+repelin	0.0125 + 0.50	8.57 (17.02)
12	Bactospeine+fenpropathrin	0.075 + 0.01	3.64 (11.00)
13	Bactospeine+monocrotophos	0.075 + 0.027	4.91 (12.80)
14	Bactospeine+carbaryl	0.075 + 0.075	6.85 (15.17)
15	Bactospeine+repelin	0.075 + 0.50	8.68 (17.13)
16	Control		12.62 (20.81)
	S.Ed		0.07
	CD (0.05)		0.15

Fig 1 : Efficacy of insectcidel treatments agianst shoot and fruit borer, (*Leucinodes orbonalis*) in brinjal

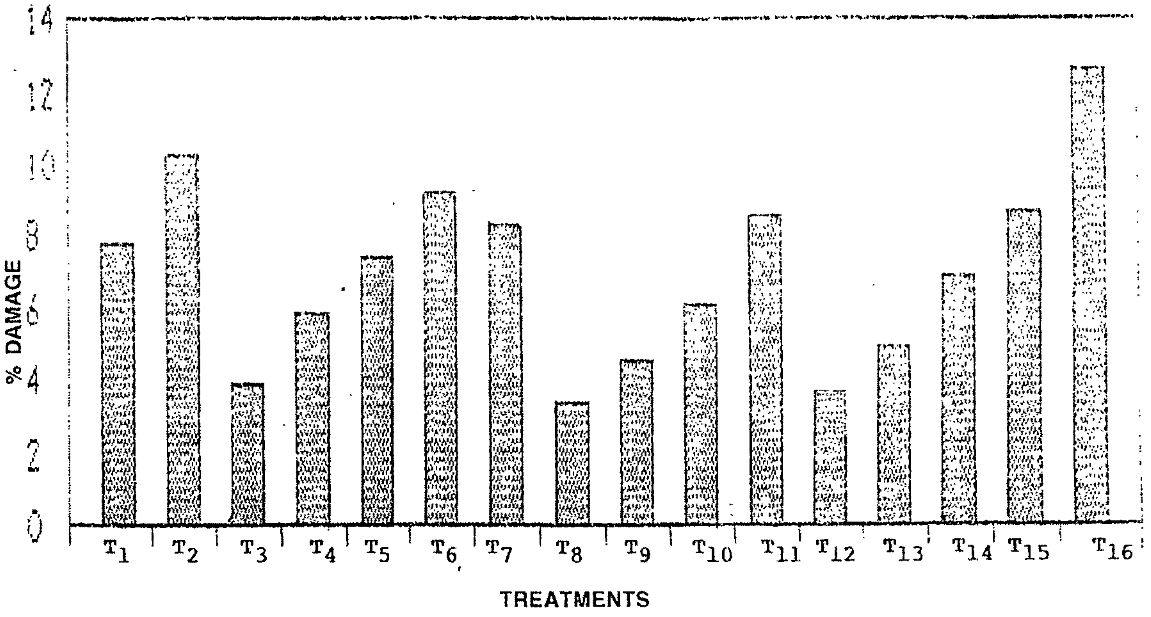


Table 2 : Efficacy of insecticides on yield in brinjal

S.No.	Treatment	Dose	Mean fruit yield		%increase over control
			kg plot^{-1}	kg ha^{-1}	
1	Diflubenzuron	0.025	32.85	16425	35.74
2	Bactospeine	0.15	28.30	14150	16.94
3	Fenpropathrin	0.02	39.10	19525	61.36
4	Monocrotophos	0.054	38.15	19075	57.64
5	Carbaryl	0.15	35.50	17750	46.69
6	Repelin	1.00	27.90	13950	15.29
7	Diflubenzuron+bactospeine	0.0125 + 0.075	29.00	14500	19.83
8	Diflubenzuron+fenpropathrin	0.0125 + 0.01	43.00	21500	77.69
9	Diflubenzuron+monocrotophos	0.0125 + 0.027	39.00	19500	61.16
10	Diflubenzuron+carbaryl	0.0125 + 0.075	37.50	18750	54.96
11	Diflubenzuron+repelin	0.0125 + 0.50	33.05	16525	36.57
12	Bactospeine+fenpropathrin	0.075 + 0.01	41.90	20950	73.14
13	Bactospeine+monocrotophos	0.075 + 0.027	37.75	18875	55.99
14	Bactospeine+carbaryl	0.075 + 0.075	36.85	18425	52.27
15	Bactospeine+repelin	0.075 + 0.50	29.60	14800	22.31
16	Control		24.20	12100	
	S.Ed		0.41		
	CD (0.05)		0.85		

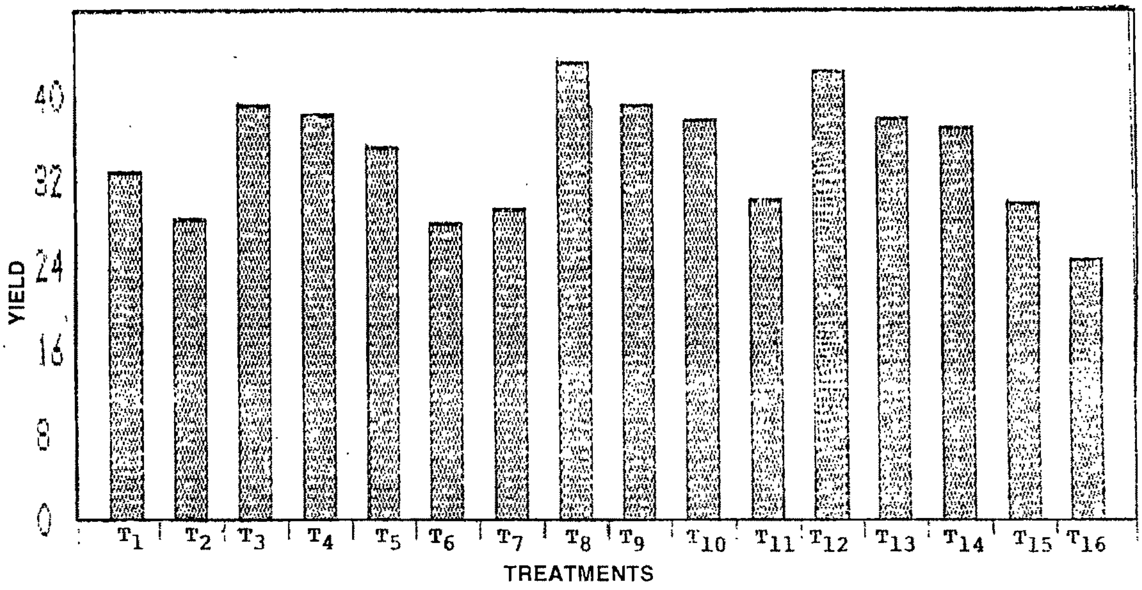
to know the effect of treatments in controlling the pest population and thereby resulting in higher yields. The data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Cumulative data on per cent infestation of shoot and fruit borer as evidenced by bored fruits to total number of fruits is furnished in Table 1 and Fig 1. All the treatments were significantly superior to control in reducing the fruit borer incidence. However no treatment gave complete control against fruit borer. The borer incidence in different treatments ranged between 3.38-10.20 per cent whereas in control it was 12.62 per cent. Diflubenzuron + fenpropathrin was found to be the most effective in controlling borer with as low as 3.38 per cent infestation and significantly superior to the rest of the treatments. Bactospeine + fenpropathrin showed 3.64 per cent followed by fenpropathrin with 3.88 per cent mean infestation of the borer. The borer infestation was 4.58 and 4.91 per cent in the plots treated with diflubenzuron + monocrotophos and bactospeine + monocrotophos, respectively. Carbaryl, diflubenzuron and diflubenzuron + bactospeine proved moderate in bringing down the incidence with 7.35, 7.85 and 8.37 per cent infestation, respectively. Repelin and bactospeine were found to be the least effective among all the treatments with as low as 9.19 and 10.20 per cent borer incidence.

Significant increase in yield was observed in all the treatments ranging between 28.3-39.05 kg/plot over control with 24.2 kg/plot (Table 2, Fig. 2). Plot that received diflubenzuron + fenpropathrin realized highest fruit of 43 kg followed by bactospeine + fenpropathrin which recorded 41.90 kg/plot and the increase in yield was 77.69 per cent and 73.14 per cent respectively, over control. The next best treatments were fenpropathrin (39.05 kg) and diflubenzuron + monocrotophos (39 kg), recording an yield increase of 61.36 and 61.16 per cent over control. Diflubenzuron + Repelin (33.05 kg) and diflubenzuron (32.85 kg) also recorded fairly

Fig 2 : Effect of insectcides on fruit yield in brinjal



good yield with 36.57 and 35.74 per cent increase over control and were on par with each other. Though Repelin (27.9 kg) was the least effective among all the treatments, it realized 15.29 per cent increase and was on par with bactospeine (28.3 kg) which gave 16.94 per cent increase in yield over control.

Results obtained during the present investigation with regard to efficacy of treatments against fruit borer clearly indicate that the coventionals in combination either with diflubenzuron or bactospeine are better in bringing down the borer incidence than the individual treatments. Diflubenzuron alone showed moderate efficacy while bactospeine and Repelin showed poor efficacy. Chandrasekhar (1989) reported better control of bhendi fruit borer and also better yields with diflubenzuron in combination with conventionals. Diflubenzuron alone and in combination with carbaryl was most effective against *Leucinodes orbonalis* (Srinivas *et al.,* 1986). Dipel in combination with carbaryl gave promising control of all the brinjal pests (Sekhar and Baskaran, 1976). Dipel 8@2ml/lt gave 8.78 per cent damage resulting in an yield of 12.07 t/ha as against the yield of the 9.98 t/ha in control whereas Dipel 8@1ml/lt+Methomyl@0.8gm/lt gave the highest yield of 16.4 t/ha (Qureshi *et al.,* 1998). Probably diflubenzuron and bactospeine might have increased susceptibility of fruit borer to conventionals by affecting the physiology of the pest. Gupta and Katiyar (1987) reported very good control of cotton bollworms with fenpropathrin. Lowest incidence of fruit borer was observed with fenvalerate (Mishra and Mishra, 1995). Good degree of efficacy obtained with monocrotophos is in conformity with the report (Ayyanna *et al.,* 1976). Many reports are available with regard to efficacy of carbaryl against fruitborer (Datar

1983). Synthetic pyrethroids (Cypermethrin 0.01%, fenvalerate 0.01%) were better than Neemrk 0.5% against *Leucinodes* (Temurde *et al.*; 1992). Monocrotophos, diflubenzuron, quinalphos and endosulfan all gave better control compared to Repelin (Rahman, 1990). The components of Repelin might not have showed any effect on borer while it was entering into the fruit.

The relative effect of treatments on fruit yield indicate that conventionals in combination either with diflubenzuron or bactospeine realized higher yield when compared to individual treatments. The differences in fruit yield is probably due to the overall effect of the treatments on pest complex of brijal. Conventional insecticides alone showed good degree of efficacy initially (at one day after spraying) against all the pests, the efficacy declined gradually except in case of fenpropathrin. Although combinations proved less effective initially, the efficacy picked up gradually and showed good control of majority of pests. Thus the overall effect of treatments resulted in higher yield in combinations of conventionals with diflubenzuron and bactospeine when compared to individual treatments. Environmentally safer diflubenzuron and bactospeine fit well into the IPM strategies if used in combination with conventionals at far lower doses.

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Seasonal Incidence and Control of *Nephopteryx eugraphella* Rag. on Cashew

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ABSTRACT

Study on the incidence and influence of various weather factors on cashew apple and nut borer, *Nephopteryx eugraphella* Rag. at Cashew Research Station, Bapatla during 2004-05 revealed peak incidence of the pest during February with non-significant relation between abiotic factors and infestation of apple and nut borer. Three insecticides *viz.*, spinosad (0.015%), thiodicarb (0.075%) and profenofos (0.05%) were proved equally effective followed by chlorpyriphos (0.05%) and cartap hydrochloride (0.05%). Neem oil and *B.t.* proved inferior as straight insecticides.

Key Words : Seasonal Incidence, Control, Apple and Nut borer

Cashew (*Anacardium occidentale* L.) is a potential crop for transformation of waste lands into economic means of income and generate substantial employment potential in industrial and rural sector (Balasubramanian, 1998). Cashew is cultivated in an area of 1.36 lakh hectares in Andhra Pradesh. Of late the ravages caused by apple and nut borer, *Nephopteryx eugraphella* Rag. has resulted in substantial crop losses. Dharmaraju *et al.* (1975) has reported 60 per cent damage by this pest. Keeping ecological principles in view the present investigation was taken up to study the incidence of apple and nut borer and its control with less persistent and ecofriendly chemicals.

MATERIAL AND METHODS

The studies were carried out at the Cashew Research Station, Bapatla during June 2004 to May 2005. The seasonal incidence data were collected at weekly intervals by placing a frame of 1.0 m^2 area on the tree canopy on all the four sides on total number of nuts, number of nuts damaged and expressed as per cent nuts damaged. The influence of weather factors on pest infestation were analysed.

Studies on chemical control of apple and nut borer was carried out in a randomised block design with ten treatments including untreated control, replicated thrice with two trees per replication (Table 1). Foot sprayer was used for applying the insecticides. The observations on the pest incidence were recorded one day before application of treatments as pre-treatment count while post-treatment counts were taken at 5, 10, 20 and 30 days after spraying. The data with regard to number of nuts damaged, reduction in larval numbers were subjected to statistical analysis after transformation of data.

RESULTS AND DISCUSSION

The seasonal incidence of apple and nut borer was studied by recording per cent damaged nuts throughout the year. The apple and nut borer infestation was observed during first week of January to first week of May with peak infestation during last week of February (16.19%). The cashew suffered with apple and nut borer incidence coinciding with apple and nut formation (Fig. 1). Studies on the interaction between the apple and nut borer incidence and abiotic components have indicated no significant

Table 1 : Effect of insecticidal spray on apple and nut borer, (*Nephopteryx eugraphella* Rag.) in cashew

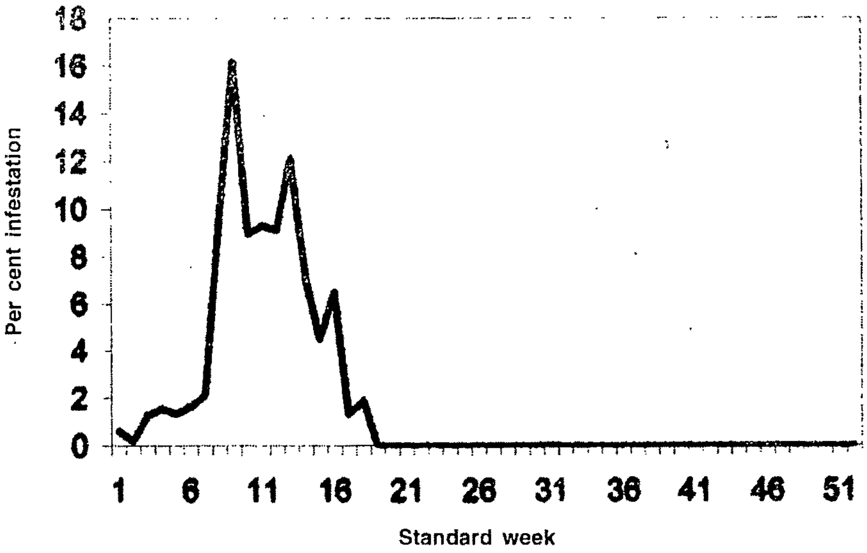
	Treatments	Mean population before treatment larvae / 4 m²	Mean per cent reduction over untreated control				Mean efficacy
			5 DAT	10 DAT	20 DAT	30 DAT	
T_1 :	Chlorpyriphos 0.05%	12.22	63.85 (53.07)	59.37 (50.41)	53.99 (47.29)	30.80 (33.70)	52.00 (46.14)
T_2 :	Thiodicarb 0.075%	11.40	66.42 (54.64)	63.06 (52.58)	57.41 (49.27)	45.13 (42.19)	58.00 (49.60)
T_3 :	Profenophos 0.05%	12.33	62.90 (52.50)	60.70 (51.18)	55.91 (48.41)	44.33 (41.73)	55.95 (48.42)
T_4 :	Cartap hydrochloride 0.05%	11.41	63.75 (52.98)	60.35 (50.99)	52.10 (46.21)	32.70 (34.79)	52.22 (46.27)
T_5 :	Spinosad 0.015%	12.04	64.10 (53.19)	62.08 (52.00)	56.80 (48.97)	44.99 (42.11)	56.99 (49.02)
T_6 :	Neemoil 0.5%	10.21	35.55 (36.60)	34.85 (36.17)	32.16 (34.51)	29.92 (33.12)	33.27 (35.22)
T_7 :	*B.t.* 0.2%	11.31	37.37 (37.68)	35.54 (36.59)	34.40 (35.73)	28.01 (31.89)	33.81 (35.53)
T_8 :	Chlorpyriphos + neem oil (0.025%+0.25%)	10.71	48.66 (44.22)	45.99 (42.69)	35.48 (36.55)	30.85 (33.69)	40.15 (39.31)
T_9 :	Chlorpyriphos + *B.t.* (0.025%+0.1%)	11.14	50.48 (45.28)	49.75 (44.86)	35.76 (36.72)	30.14 (33.28)	41.51 (40.11)
T_{10} :	Check	11.70	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	F test	NS	Sig	Sig	Sig	Sig	Sig
	CD (P=0.05)		4.31	3.79	6.45	3.76	2.74

Figures in parantheses are angular transformed values.
Sig - significant, NS - Non-significant, DAT - Days after treatment

relationship with any of the selected abiotic factors in agreement with Ramadevi and Radha krishnamurthy (1983) and Chatterjee (1988) who reported highest incidence during February onwards.

With regard to the bioefficacy of insecticides thiodicarb, spinosad, chlorpyriphos, cartap hydrochloride and profenophos were found to be equally effective followed by combination treatments of chlorpyriphos + *B.t.* and chlorpyriphos + neem oil, on fifth day after spraying and the same trend was observed even at ten and twenty days after spraying. However, chlorpyriphos and cartap hydrochloride treatments were relegated to second position at thirty days after treatment (Table 1). The overall efficacy of treatments against larval population of apple and nut borer showed that the insecticides thiodicarb (0.075%), spinosad (0.015%) and profenophos (0.05%) were followed by chlorpyriphos (0.05%) and cartap hydrochloride (0.05%). The better efficacy of profenophos against cashew pests was already reported by Suvarnaraju (1996). The lower efficacy of combination treatments and neem, *B.t.* alone treatments suggest that the dose might not be enough to have on par results as that of

Fig 1 : Seasonal Incidence of apple and nut borer (2004-2005) in cashew



straight insecticides and secondly the apple and nut borer had the habit of boring into apples and nuts and thus protecting the larvae coming in contact with insecticides directly. So the efficacy of these biorationals *viz., B.t.* and neem insecticides might have lost.

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Seasonal Activity and Management of Brinjal Fruit and Shoot Borer, *Leucinodes orbonalis* Guenee

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ABSTRACT

The effect of climatological parameters against the fruit damage was negatively and non-significantly correlated. Among the treatments T_3 (carbaryl + cartap hydrochloride + endosulfan + diflubenzuron + multineem + chlorpyriphos) was most effective in reducing the shoot and fruit borer infestation in brinjal.

Key Words : Seasonal Activity, Brinjal Fruit and Shoot Borer, Insecticides

Solanum melongena L. var melongena, a prominent vegetable crop, includes the common egg plant with large, pendent, ovoid, oblong or obovoid berries. As far as vegetable production in the global scenario is concerned, India occupies the second position after China. It is estimated that approximately 32.2% area comes under local varieties. The average productivity of brinjal in India has been estimated to be 130.8 q ha.

Frempong (1978) stated that brinjal crop is ravaged by 140 species of insect pests. About 70 species of insect and non-insect pests have been reported to occur in India. Among these pests, the most disastrous insect pest is shoot and fruit borer, *Leucinodes orbonails* Guenee. The pest causes 15-45% shoot damage and 30-99% of fruit damage. Therefore, the present investigation is mainly aimed at evaluating effective chemical control schedules against the pyralid borer *Leucinodes orbonalis* on brinjal.

MATERIAL AND METHODS

In order to study the seasonal activity and extent of damage of the shoot and fruit borer (*Leucinodes orbonalis* Guen.) on brinjal crop, and to evolve an appropriate control schedule against this pest under Bhubaneswar agro-climatic situation, a field experiment was undertaken in the experimental farm of Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during the cropping period from November 2002 - April 2003. To record shoot damage before the initiation of the fruits, the shoots of all plants of each sub-plot were examined and damaged fruits were counted. To record the damaged fruits, on the date of picking of fruits, the number of total fruits, number of healthy fruits and number of damaged fruits were counted from each harvested sub-plot. Such types of observations were taken at 15 days interval on each date of pesticidal application. Recording of shoot infestation commenced from 30 DAT and continued upto 100 DAT in fortnightly interval. The shoot and fruit damage were converted into percentage of infestation. The fruit yield (q/ha) was recorded on different dates of harvest. The different treatments are presented in Table 1.

Table 1 : Treatment schedule of the experiment (No.of Treatments - 7) to control brinjal fruit and shoot borer

Treatments	Dose (kg ha^{-1})
T_1 Carbofuran at 30 DAT	2.0
+ Cartap hydrochloride at 45 DAT	0.5
+ Cypermethrin at 60 DAT	0.1
+ Diflubenzuron at 75 DAT	0.075
+ Endosulfan at 90 DAT	0.5
+ Fenvalerate at 105 DAT	0.1
T_2 Cartap hydrochloride at 30 DAT	0.5
+ Monocrotophos at 45 DAT	0.5
+ Carbaryl at 60 DAT	1.0
+ Cypermethrin at 75 DAT	0.1
+ *Bt* formulation at 90 DAT	1.5 (kg ha^{-1})
+ Endosulfan at 105 DAT	0.5
T_3 Carbaryl at 30 DAT	1.0
+ Cartap hydrochloride at 30 DAT	0.5
+ Endosulfan at 60 DAT	0.7
+ Diflubenzuron at 75 DAT	0.07
+ Azadirachtin at 90 DAT	6ppm/1t
+ Chlorpyriphos at 105 DAT	0.4
T_4 Endosulfan at 30 DAT	0.7
+ Monocrotophos at 45 DAT	0.5
+ Cartap hydrochloride at 60 DAT	0.5
+ Cypermethrin at 75 DAT	0.1
+ *Bt* formulation at 90 DAT	1.5 (kg ha^{-1})
+ Cartap hydrochloride at 105 DAT	0.5
T_5 Chlorpyriphos at 30 DAT	0.4
+ Carbaryl at 45 DAT	1.0
+ *Bt* formulation at 60 DAT	1.5 (kg ha^{-1})
+ Diflubenzuron at 75 DAT	0.075
+ Endosulfan at 90 DAT	0.7
+ Carbaryl at 105 DAT	1.0
T_6 Azadirachtin at 30 DAT	250 (kg ha^{-1})
+ Carbaryl at 45 DAT	1.0
+ Diflubenzuron at 60 DAT	0.07
+ Fenvalerate at 75 DAT	0.1
+ Cartap hydrochloride at 90 DAT	0.5
+ Monocrotophos at 105 DAT	0.5
T_7 - Control	

The data recorded on various aspects of experiment were statistically analysed after transformation according to Snedecor and Cochran (1967) to test the level of significance of treatments. Squareroot transformations were employed when the percentage data was in between 0 and 30% or 70 and 100 per cent. In case of small figures on percentage data particularly when zeros were present, (x = %) was used for transformation.

Table 2 : Incidence of shoot infestation (%) caused by brinjal shoot and fruit borer during *rabi* 2002-03 at Bhubaneswar

Treatments	25 DAT	40 DAT	55 DAT	70 DAT	85 DAT	100 DAT	Mean	% decrease over control (T_7)
T_1	2.51 (1.73)	2.04 (1.59)^{a}	6.53 (2.65)^{a}	6.20 (2.59)^{bc}	4.19 (2.17)^{bc}	2.76 (1.80)^{b}	4.04 (2.13)	58.35
T_2	2.00 (1.58)	2.00 (1.58)^{a}	7.84 (2.88)^{ab}	7.28 (2.79)^{cd}	4.24 (2.18)^{c}	2.70 (1.79)^{b}	4.34 (2.20)	55.25
T_3	1.95 (1.56)	2.17 (1.63)^{a}	8.57 (3.01)^{bc}	4.07 (2.13)^{a}	3.05 (1.88)^{a}	2.09 (1.61)^{a}	3.65 (2.04)	62.37
T_4	2.38 (1.70)	2.50 (1.73)^{a}	7.03 (2.74)^{a}	6.27 (2.60)^{bcd}	4.01 (2.12)^{b}	2.68 (1.78)^{ab}	4.14 (2.15)	57.32
T_5	2.54 (1.74)	2.27 (1.66)^{a}	9.01 (3.08)^{c}	8.50 (3.00)^{d}	7.69 (2.86)^{d}	5.71 (2.49)^{c}	5.95 (2.54)	38.66
T_6	2.42 (1.71)	2.67 (1.78)^{a}	7.37 (2.80)^{ab}	5.60 (2.47)^{b}	4.04 (2.13)^{bc}	2.70 (1.78)^{ab}	4.13 (2.15)	57.42
T_7	2.46 (1.68)	5.09 (2.36)^{b}	15.77 (4.03)^{d}	15.50 (3.98)^{e}	12.21 (3.56)^{e}	7.19 (2.77)^{d}	9.70 (3.19)	-
Mean	2.32 (1.68)	2.68 (1.76)	8.14 (2.94)	7.63 (2.85)	5.63 (2.48)	3.69 (2.05)	-	-
Sem (±)	0.043	0.086	0.081	0.065	0.017	0.057	-	-
CD (P=0.05)	-	(0.27)	(0.25)	(0.20)	(0.05)	(0.17)	-	-

DAT : Days after transplanting

Figures in parentheses are $\sqrt{(x+0.5)}$

Similar superscripts in the column indicate that their differences are not statistically significant at P=0.05

RESULTS AND DISCUSSION

The recording of shoots infestation commenced from 25 DAT (days after transplanting) and continued upto 100 DAT. It was observed from the mean shoot infestation during the cropping period attained its peak activity at 55 DAT. During this period, the mean temperature (25.25° C) and mean relative humidity (68%) were congenial to favour the pest to cause peak shoot infestation. The average range of shoot infestation during course of investigation varied from 3.65 to 9.70 per cent.

Effect of insecticidal schedule on the brinjal shoot infestation

It was revealed that the treatments T_1 (carbofuran 3G @ 2kg a.i/ha) and T_5 (chloropyriphos 20 EC @ 0.4 kg a.i/ha) applied in the first spraying schedule reduced the shoot infestation to the extent of 18.72 and 10.63 per cent, respectively. Application of pesticides *viz.*, cypermethrin, carbaryl, endosulfan; cartap hydrochloride, Halt, diflubenzuron at 55 DAT reduced the shoot infestation to the extent of 5.05, 7.14, 52.51, 10.81, 5.66 and 24.02 per cent, respectively. It was also revealed that endosulfan, cartap hydrochloride and difubenzuron were quite effective to minimize shoot infestation.

In order to summarize the shoot infestation the effectiveness of pesticidal schedules in reducing shoot damage after application of each pesticidal schedule was taken into consideration. The mean percentage of reduction of shoot infestation clearly indicated the effectiveness of pesticidal schedule. It was evident that the

Table 3 : Extent of fruit damage caused by brinjal shoot and fruit borer during *rabi* 2002-03 at Bhubaneswar

Treatments	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	150 DAT	165 DAT	Mean	% decrease over control (T_7)
T_1	12.47 (3.58)^{ab}	8.46 (2.99)^{a}	7.82 (2.88)^{a}	7.49 (2.82)^{bc}	15.27 (3.96)^{c}	19.74 (4.50)^{b}	19.86 (4.50)^{ab}	13.01 (3.68)	35.97
T_2	12.92 (3.63)^{ab}	9.52 (3.16)^{a}	8.31 (2.96)^{a}	8.88 (3.06)^{c}	13.67 (3.76)^{ab}	19.64 (4.48)^{b}	19.02 (4.42)^{ab}	13.14 (3.69)	35.33
T_3	9.73 (3.19)^{a}	9.73 (3.19)^{a}	6.14 (2.55)^{a}	7.85 (2.89)^{bc}	14.39 (3.85)^{bc}	14.56 (3.88)^{a}	18.30 (4.33)^{ab}	11.07 (3.40)	45.52
T_4	10.00 (3.24)^{a}	8.97 (3.07)^{a}	7.01 (2.73)^{a}	7.01 (2.74)^{bc}	11.63 (3.50)^{ab}	19.14 (4.43)^{b}	20.12 (4.54)^{b}	12.15 (3.56)	40.21
T_5	16.24 (4.09)^{b}	13.14 (3.69)^{b}	11.56 (3.47)^{b}	5.28 (2.37)^{a}	16.02 (4.06)^{c}	15.05 (3.94)^{a}	17.59 (4.25)^{ab}	13.55 (3.75)	33.32
T_6	11.11 (3.40)^{a}	8.89 (3.06)^{a}	7.63 (2.84)^{a}	6.09 (2.56)^{ab}	11.52 (3.46)^{a}	18.98 (4.41)^{b}	16.95 (4.41)^{b}	11.59 (3.48)	42.96
T_7	29.63 (5.48)^{c}	25.76 (5.12)^{c}	20.94 (4.63)^{c}	13.79 (3.78)^{d}	18.75 (4;39)^{d}	16.20 (4.09)^{a}	17.18 (4.20)^{a}	20.32 (4.56)	-
Sem (±)	0.188	0.130	0.137	0.114	0.120	0.087	0.106	-	-
CD (P=0.05)	(0.58)	(0.40)	(0.42)	(0.35)	(0.37)	(0.27)	(0.33)	-	-

DAT : Days after transplanting

Figures in parentheses are $\sqrt{(x+0.5)}$

Similar superscripts in the column indicate that their differences are not statistically significant at P=0.05

pesticidal schedule T_3 (carbary1 + cartap hydrochloride + endosulfan + diflubenzuron + Multineem + chloropyriphos) proved to be the most effective schedule to minimize the shoot infestation satisfactorily. Other promising pesticidal schedules were T_6 (Neemcake + carbaryl + difubenzuron + fenvalerate + cartap hydrochloride + monocrotophos) and T_4 (endosulfan + monocrotophos + cartap hydrochloride + cypermethrin +*Bt* formulation + cartap hydrochloride).

To consider the effectiveness of different treatments during the course of shoot infestation values were taken into account. It was revealed from the mean investigation values that treatment T_3 was quite effective to reduce shoot infestation. The mean shoot infestation caused by different treatments are arranged in the following order *i.e.* T_3 (3.65%) < T_1 (4.04%)< T_6 (4.13%)< T_4 (4.14%) < T_2 (4.34 %)< T_5 (5.95%) < T_7 (9.70%). Application of endosulfan, cartap hydrochloride, diflubenzuron, *Bt* formulation (Halt) and azadirachtin (Multineem) were quite effective to decrease the shoot infestation satisfactorily. These findings corroborate with the findings of previous workers (Jagamohan, 1980; Choudhary and Roy 1985; Bothra and Dethe, 1991; Patil *et al.,* 1991and Singh *et al.*, 1996). The treatment T_3 caused 62.37% reduction in shoot damage over control. Application of carbaryl, cartap hydrochloride, endosulfan, diflubenzuron, Multineem and chloropyriphos at 15 days interval starting from 30DAT to 105 DAT registered lowest fruit damage and heighest fruit yield (Table 2).

Effect of pesticidal schedule on brinjal fruit infestation

In order to know the extent of fruit infestation, periodical damaged fruits indicating

Table 4 : Healthy fruit yield of brinjal (q ha^{-1})

Treatments	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	150 DAT	165 DAT	Total	Benefit cost ratio
T$_1$	7.47^{bc}	16.07^{c}	49.11^{c}	42.86^{c}	28.57^{b}	16.61^{b}	6.07^{a}	166.76	3.40 : 1
T$_2$	4.17^{a}	11.90^{b}	36.31^{c}	42.56^{c}	40.71^{d}	23.09^{c}	10.12^{ab}	168.87	3.06 : 1
T$_3$	8.78^{c}	15.77^{c}	44.94^{d}	46.87^{d}	48.36^{f}	25.74^{c}	6.13^{a}	196.61	3.76 : 1
T$_4$	7.35^{bc}	6.73^{a}	38.09^{c}	46.43^{d}	46.28^{ef}	23.99^{c}	8.96^{ab}	177.83	3.66 : 1
T$_5$	4.37^{a}	8.69^{a}	28.87^{b}	38.54^{b}	34.23^{c}	17.79^{b}	7.68^{ab}	140.20	2.61 : 1
T$_6$	8.18^{c}	7.68^{a}	41.96^{d}	56.84^{c}	43.01^{de}	16.78^{b}	8.81^{ab}	183.27	3.66 : 1
T$_7$	5.24^{ab}	11.37^{b}	25.89^{a}	29.76^{a}	23.30^{a}	13.69^{a}	8.36^{ab}	117.62	-
CD (P=0.05)	(2.38)	(2.67)	(2.89)	(3.28)	(4.03)	(2.48)	(3.10)	-	-

healthy fruits at fortightly interval commenced from 75 DAT and continued upto 165 DAT. The data were then converted into percentage of damage.

It was revealed that the third insecticidal schedule treatments *viz.*, T$_1$, T$_2$, T$_5$ and T$_6$ were effective to reduce fruit damage. Similarly at 90 DAT and 105 the treatments *viz.*, T$_1$, T$_2$, T$_3$, T$_4$ and T$_5$ produced same level of efficacy against the brinjal shoot and fruit borer. There was no significant difference among the treatments, whereas, at 120 DAT the findings of the treatments of T$_1$, T$_3$ and T$_4$ were at par. After the completion of last insecticidal schedule, the extent of fruit damage was within 5.28 to 8.88 per cent. Then there was an increase of fruit damage upto 165 DAT. Analyzing the mean percentage of fruit infestation during cropping period, it was evident from that out of all of the treatments T$_3$ (carbaryl + cartap hydrochloride+ edosulfan+diflubenzuron+Multineem+ chlorpyriphos) was most effective to reduce pest infestation. Other two promising pesticidal schedules were T$_6$ (Neem cake+carbaryl+ diflubenzuron+fenvalerate+cartap hydrochloride+monocrotophos) and T$_4$ (endosulfan+monocrotophos+cartap hydrochloride+cypermethrin+Halt+cartap hydrochloride). In order to asses the extent of fruit infestation. periodical observations on fruit damage (%) commenced from 75 DAT and continued upto 165 DAT. It was revealed from the studies that application of cypermethrin, carbaryl, Halt and diflubenzuron at 60 DAT were equally effective. Similarly use of endosulfan, Halt and azadirachtin at 90 DAT and fenvalerate, endosulfan, chlorpyriphos, cartap hydrochloride and carbaryl at 105 DAT were also effective to reduce brinjal shoot and fruit borer damage. To evolve the suitable treatment schedule the mean fruit damage (%) during the cropping period was analysed critically. It is clearly noticed from the studies that T$_3$ treatment was most effective to decrease fruit damage. The efficacy of different pesticidal treatments is presented as follows : T$_3$ (11.07)> T$_6$ (11.59%) > T$_4$ (12.15%)> T$_2$ (13.14%) > T$_5$ (13.55%).

Our studies indicated that application of endosulfan @ 0.5 kg a.i./ha, at 60 DAT produced promising results to reduce fruit damage. Whereas Choudhary *et al.* (1993) from Bangladesh pin pointed that use of endosulfan @ 0.7 kg a.i/ha at 20 DAT performed satisfactorily in suppressing the pest damage (Table 3).

Yield of healthy fruits

It was evident from Table 4 that increase of fruit yield was found upto 120 DAT in treatments like T_2, T_4, T_5 and T_6 whereas, the treatment schedule *viz.*, T_3 and T_4 recorded the increasing higher yield upto 135 DAT. The last insecticidal schedule (105 DAT) of T_2, T_4, T_5 and T_6 were quite effective to increase fruit yield upto 120 DAT. After which there was a decline in the fruit yield. T_3 and T_6 treatments were most effective and recorded higher yield.

Analysis of benefit : cost ratio

It is revealed from above table that the most effective pesticidal schedule *viz.*, T_3 produced the highest benefit : cost ratio of 3.76:1. Other promising pesticidal schedules were T_4, T_5 and T_1 which registered the benefit : cost ratio of 3.66:1 and 3.40:1, respectively. The pesticidal schedule *viz.*, T_5 was not encouraging to record the higher benefit : cost ratio (Table 5).

Correlation coefficient between meteorological variables and brinjal shoot and fruit borer damage

The effect of climatological parameters *viz.*, maximum temperature, minium temperature, relative humidity and rainfall have been studied. The correlation between fruit yield and extent of fruit damage has also been worked out.

It was revealed that the fruit damage was negatively and non-significantly correlated with maximum temperature (-0.819), minimum temperature (-0.863), mean temperature (-0.851), relative humidity (-0.654) and rainfall (-0.190). The fruit yield associated negatively and non-significantly (-0.588) with fruit damage.

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Seasonal Incidence and Management of *Spodoptera exigua* (Hubner) on Fenugreek (*Trigonella foenum-graceum* Linn.)

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ABSTRACT

A field experiment was conducted to study the incidence and to evaluate new ecofriendly chemical insecticides against *Spodoptera exigua* (Hubner) on fenugreek during *rabi* 2004-05 at Agricultural College Farm, Bapatla. Peak incidence of tobacco caterpillar in terms of larvae was observed during last week of December 2004 and the incidence had no significant relationship with weather parameters selected. The results of chemical control trial indicated that indoxacarb (0.0145%) and thiodicarb (0.075%) were the most effective in reducing larval population of *S. exigua* besides recording higher fenugreek seed yield.

Key words : Fenugreek, *Spodoptera exigua*. Seasonal incidence, Indoxacarb, Thiodicarb

Fenugreek (*Trigonella foenum -graceum* Linn.) is one of the spice crops grown in India with an area of 38.5 thousand hectares and production of about 50 thousand tonnes (Arya, 2000). Fenugreek is gaining importance in the Krishna-Godavari zone of Andhra Pradesh in the *rabi* season. Its cultivation is influenced by so many pests and diseases and especially *Spodoptera exigua* Hub, is threatening its cultivation. As this crop is new to K.G. Zone, the present study was initiated to work out its seasonal dynamics besides evaluation of certain new ecofriendly chemicals.

MATERIAL AND METHODS

The studies were conducted at Agricultural College Farm, Bapatla during *rabi* 2004-05. Lam sel-1, a popular variety of fenugreek was cultivated in a bulk plot of 200 m^2 by adopting in inter-and intra-row spacing of 30x10cm for recording seasonal incidence data. Pest incidence was recorded on 50 randomly selected plants at five different locations, soon after noticing the infestation and was continued upto maturity of the crop at four days interval. The pest incidence was correlated with meteorological data for establishing the influence of weather parameters on the activity of the pest. The influence of weather parameters on the incidence of *S. exigua* was established through simple correlation and multiple linear regression studies.

For management of *S. exigua* on fenugreek, the experiment was laid in a simple randomised block design (RBD) with 10 treatments including the untreated check and replicated thrice. Plots of net size 5mx4m were prepared and enclosed by bunds all round and with irrigation channels in between the replications.

Eight different insecticides, *viz.*, acephate 75WP (0.1%), chloropyriphos 20 EC (0.05%), indoxacarb 14.5 SC (0.0145%), thiodicarb 75 WP (0.075%), dimethoate 30 EC (0.03%), novaluron 10 EC (0.1%), nimbicidine (0.2%) and a combination of chlorpyriphos 20 EC (0.025%) + novaluron 10 EC (0.05%) were used in the chemical control trails.

Table 1 : Simple correlation between larval population of *S. exigua* and weather parameters on fenugreek (*rabi*, 2004-05)

Weather parameters	Correlation coefficient (r)
X_1 - Maximum temperature	-0.3693 NS
X_2 - Minimum temperature	0.4260 NS
X_3 - Relative humidity (8.30hrs)	0.2300 NS
X_4 - Relative humidity (17.30hrs)	0.0483 NS
X_5 - Wind speed	-0.0410 NS

NS = non-significant r_{tab} - value = 0.480

Table 2 : Multiple linear regression analysis of larval populations of *S. exigua* on certain weather parameters on fenugreek (*rabi*, 2004-05)

Variable	Partial regression coefficient	Standard error	t-value
X_1 - Maximum temperature (°C)	-0.547	2.05	0.260 NS
X_2 - Minimum temperature (°C)	-2.28*	0.79	2.860*
X_3 - Morning relative humidity (%)	0.098	0.23	0.429 NS
X_4 - Evening relative humidity (%)	0.44	0.22	1.989 NS
X_5 - Wind speed	0.67	0.71	0.944 NS

Intercept : 18.66 R^2 value = 0.4645
*significant at 5% level t_{tab} - value = 2.131 at 5% level NS = non-significant

The treatments were given as foliar sprays after the uniform infestation of the pest in the experimental plot. The crop has received two rounds of foliar spray, the first one during vegetative phase at 35 days after sowing. The larval population were recorded one day before spraying as pre-treatment count and on first, five and ten days after spraying as post-treatment counts. The observations were recorded from ten randomly selected plants which were tagged in each plot leaving the border rows.

The per cent population reduction for *S. exigua* over untreated check in different treatments was calculated using modified Abbot' s formula (Fleming and Ratnakaran, 1985) and these values were further transformed to the corresponding angular values and then data were subjected to statistical analysis.

RESULTS AND DISCUSSION

The initial infestation of the pest was noticed during fourth week of November *i.e.*, 16 days after sowing and thereafter the infestation gradually increased from 1.0 to 16.66 larvae per ten plants during 27th November to 13th December 2004 (Fig 1). Peak incidence of *S. exigua* was observed during last week of December with a pest density of 19.68 larvae per ten plants at 45 days after sowing of the crop and thereafter declined gradually with raise in temperature. Peak incidence of *S. exigua* during December was reported on onion (Rani, 2004).

The correlation studies indicated no significant relationship between the larval population of *S. exigua* and weather parameters selected (Table 1). The multiple linear regression analysis indicated significant negative

Table 3 : Efficacy of treatments after two sprayings against *S. exigua* on fenugreek during *rabi* 2004-05

Treatments	Pretreatment mean larval population/10 plants	Mean per cent reduction of larvae over control at			Mean efficacy
		1 DAS	5 DAS	10 DAS	
T_1 : Acephate 0.1%	14.55 $(50.78)^{c}$	60.02 $(59.82)^{b}$	74.70 $(51.87)^{c}$	61.85 $(54.05)^{c}$	65.53
T_2 : Chlorpyriphos 0.05%	12.00 $(35.89)^{d}$	34.37 $(52.34)^{c}$	62.68 $(44.70)^{d}$	49.48 $(44.33)^{d}$	48.84
T_3 : Imidacloprid 0.00445%	13.55 $(29.41)^{e}$	24.12 $(41.77)^{d}$	44.37 $(40.89)^{e}$	42.86 $(37.55)^{e}$	37.16
T_4 : Indoxacarb 0.0145%	16.49 $(61.00)^{a}$	76.47 $(68.77)^{a}$	86.88 $(59.50)^{ab}$	74.23 $(62.59)^{a}$	78.81
T_5 : Thiodicarb 0.075%	15.38 $(57.35)^{b}$	70.88 $(62.78)^{b}$	79.04 $(56.59)^{a}$	69.65 $(58.85)^{b}$	73.24
T_6 : Dimethoate 0.03%	13.16 $(25.99)^{f}$	19.24 $(41.91)^{d}$	44.63 $(34.09)^{f}$	31.44 $(34.36)^{f}$	31.77
T_7 : Chlorpyriphos (0.025%) IGR (novaluron) 0.005%)	13.83 $(50.06)^{c}$	58.78 $(60.34)^{b}$	75.40 $(50.80)^{c}$	60.03 $(53.56)^{d}$	64.72
T_8 : IGR (novaluron) 0.01%	15.20 $(29.27)^{e}$	23.92 $(51.80)^{c}$	61.72 $(61.75)^{c}$	77.51 $(47.35)^{d}$	54.09
T_9 : Nimbecidine (0.2%)	13.83 $(26.72)^{f}$	20.32 $(41.12)^{d}$	43.25 $(35.28)^{f}$	33.43 $(34.64)^{f}$	32.34
T_{10} : Control	17.53	-	-	-	-
F-test		Sig.	Sig.	Sig.	Sig.
SEd		1.04	1.50	1.59	0.86
CD (P=0.05)		2.19	3.15	3.33	1.82

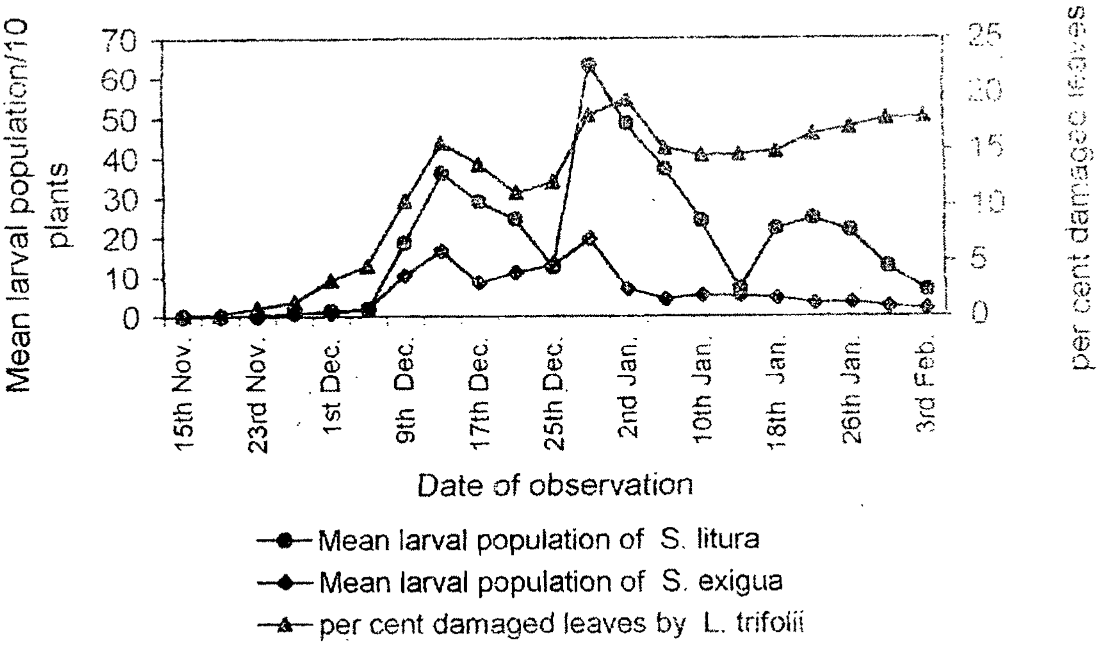
Figures in parentheses are angular transformed values; Sig = Significant ; DAS = Days after spraying
Values having common superscript are statistically non significant by DMRT

relationship of minimum temperature with the larval population. It was observed that the coefficient of determination (R^2) for larval incidence was 0.4645 which shows that the climatic factor together were able to explain the variation in the larval incidence to the extent of 46.45 out of 100 (Table 2).

In chemical control trial, the data regarding the two sprays were pooled together and the cumulative efficacy of the treatments against larval population of *S. exigua* are presented in Table 3.

The overall mean efficacy of the three observations recorded at one, five and ten days after two sprays indicated that indoxacarb (0.0145%) recorded the highest reduction (78.21%) of *S. exigua* larval population over control and also resulted in the highest yield of 1122.22 kg ha^{-1} as against 529.16 kg ha^{-1} in untreated check. This might be due to its novel molecular structure and novel mode of action and it was closely followed by thiodicarb (0.075%) which was equally effective with 73.24 per cent larval reduction and offered a higher yield of 1013.90 kg ha^{-1}. This might be possible because thodicarb being an oxime carbamate has predominant stomach action. These results on *S. exigua* were in conformity with Rani (2004) for indoxacarb and Ahmed *et al.* (2000) and Varalakshmi (2004). The next best treatments

Fig. : Incidence of pest complex on fenugreek (*rabi*, 2005-05)



were acephate 0.1 per cent (65.53%) and combination treatment of chlorpyriphos 0.025 per cent + novaluron 0.005 per cent (64.72%) being on par with each other recorded more than 920 kg ha^{-1}.

The effect of combination treatment may be due to the fact that novaluron disrupts chitin deposition and enhances the penetration of insecticides and thus lead to the increased toxicity in combinations. These findings on *S. exigua* are in confirmation with reports of Srinivas (2003) for acephate and Visalakshmi *et al.* (2000) and Varalakshmi (2004) for combination treatment. Novaluron (0.1%) and chlorpyriphos (0.05%) being on par with each other showed moderate efficacy with 54.09 and 48.84 per cent mean reduction respectively over control and recorded an intermediary yield of more than 847 kg ha^{-1}. Chlorpyriphos being non-systemic has moderate persistence with contact and stomach action. The efficacy of chlorpyriphos against *S. exigua* was also reported by Rani (2004). Novaluron is a novel benzophenyl urea compound and it acts on the larvae by inhibiting chitin formation and there by causing abortive moulting (Satapathy and Samarjit, 2004). Hence it is expected to take some time to show its efficacy after application. However it showed the highest reduction in larval population of *S. exigua* upto 77.51 per cent over control at ten days after spraying. The present results on *S.exigua* are in concordance with Sawant *et al.* (2004) who reported moderate efficacy of novaluron. The remaining treatments in the descending order of efficacy were imidacloprid 0.00445 per cent

(37.16%), nimbecidine 0.2 per cent (32.34%) and dimethoate 0.03 per cent (31.77%) are less effective and this reflected in their yield of less than 700 kg ha^{-1}.

Thus indoxacarb (0.0145%) and thiodicarb (0.075%) were most effective in reducing larval population of *S. exigua* besides recording higher fenugreek seed yield.

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New Records of Planthoppers (Delphacidae : Hemiptera) Associated with Rice Ecosystems from Andhra Pradesh

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ABSTRACT

Seven planthopper species (Delphacidae : Hemiptera) *viz., Sogatella kolophon* (Kirkaldy), *S. vibix* (Haupt), *Tagosodes pusanus* (Distant), *Tethron albovittatum* (Matsumura), *T. propinqua* (Feiber), *Harmalia anacharsis* (Fennah) and *Cemus* sp. associated with different rice ecosystems were reported for the first time from Andhra Pradesh. An illustrated key is provided to identify 10 known planthoppers from Andhra Pradesh.

Key Words : Planthoppers, Delphacidae, Hemiptera, Rice Ecosystems, Identification Key

Planthoppers belong to the family Delphacidae of Auchennorrhynchous Hemiptera. Delphacidae is the largest family of planthoppers and its members can be recognised by presence of a large flattened spur at the apex of the hind tibia. They are usually small insects, less than 5 mm in length with tectiform wings, often brachypterous, feeding mostly on monocots and also the dicots. There are about 1835 species of planthopppers of which 22 are recorded on rice (Wilson and O'Brien, 1987). They are phytophagous and more commonly feed on plants by sucking the sap. They also cause damage by plugging the xylem and phloem vessels by their feeding sheathes and also secrets honeydew, which leads to development of sooty mold. In addition to direct damage to plants, they also act as vectors for viral diseases *viz.*, grassy stunt and ragged stunt (*Nilaparvata lugens* (Stall)), rice stripe and black streaked dwarf (*Laodelphaux striatellus* (Fallen)) and hoja blanca (*Tagosodes oryzicolus* (Muir)) etc.

In the recent years there has been tremendous change in the pest status of several of the insects feeding on rice. Some of the minor pests hitherto of no importance have gained major significance. Hence, accurate identification of pest species affecting any crop is the first and foremost important step in integrated pest management programme .

MATERIAL AND METHODS

The planthopper collections were made intensively from rice ecosystems of coastal Andhra Pradesh by sweeping with the help of an insect collection net. The collected planthoppers were aspirated from the net in to a glass tube and were killed with the help of cotton swab wetted with a few drops of ethyl acetate. The killed specimens were dried in a hot air oven at 45 to 50^0 C for about four hours and stored in small glass vials. For mounting and preparing slides of genitalia the procedure suggested by Knight (1965) was followed. In the present paper the terminology advocated by O' Brien and Wilson

Fig 1-8 : General body structures of planthoppers *Nilaparvata lugens* (Stal) (from Okada, 1977)
1. Head and Thorax, dorsal view ;
v. vertex, e. eye, p. pronotum, t. tegula, m. mesonotum,
s. mesoscutellum, mc. median carina, lc. lateral carinae

2. Face
f. frons, o. ocellus, a. antenna, g. gena, c. clypeus,
r. rostrum

Fig. 3 : Hind leg-tibia and tarsus (from Wilson and Claridge, 1991)
4. Diaphragm 5. Anal tube

6. Male genitalia - ventrocaudal view;

a) anal tube b) anal style c) anal tube appendage
d) connective e) aedeagus f) gonopore g) styles

7. Hind wing 8. Tegmen (Fore wing)

Figs. 9-11 : *Sogatella furcifera* (Horvath)
9. Tegmen (Fore wing)

10. Male genitalia - lateral view, dissected

11. Genital styles

Figs. 12-14 : *Sogatella kolophon* (Kirkaldy)
12. Male genitalia - lateral view, dissected

13. Tegmen (Fore wing)

14. Genital styles

Figs. 15-17 : *Sogatella vibix* (Haupt)
15. Genital styles

16. Male genitalia - lateral view, dissected

17. Tegmen (Fore wing)

Figs. 18-19 : *Tagosodes pusanus* (Distant)
18. Male genitalia - lateral view, dissected

19. Genital styles

Figs. 20-21 : *Toya propinqua* (Fieber)
20. Genital styles

21. Tegmen (Fore wing)

Figs. 22 : *Terthron albovittatum* (Matsumura)
male genitalia - lateral view, dissected

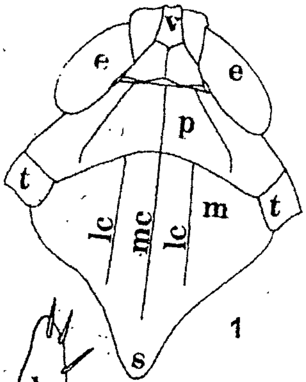
Figs. 23-24 : *Sardia rostrata* Melichar
23. Tegmen (Fore wing)

24. Male genitalia - lateral view, dissected

Figs 25 : *Harmalia anacharsis* Fennah
male genitalia - lateral view, dissected

Figs. 26-27 : *Cemus* sp.
26. Aedeagus

27. Tegmen (Fore wing)



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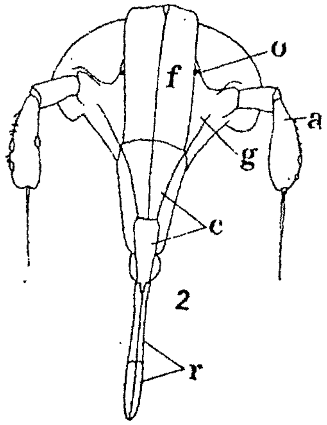

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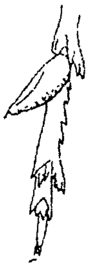

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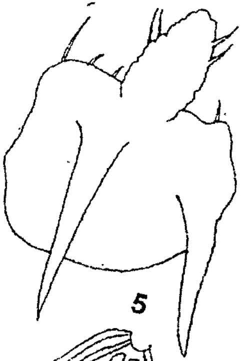

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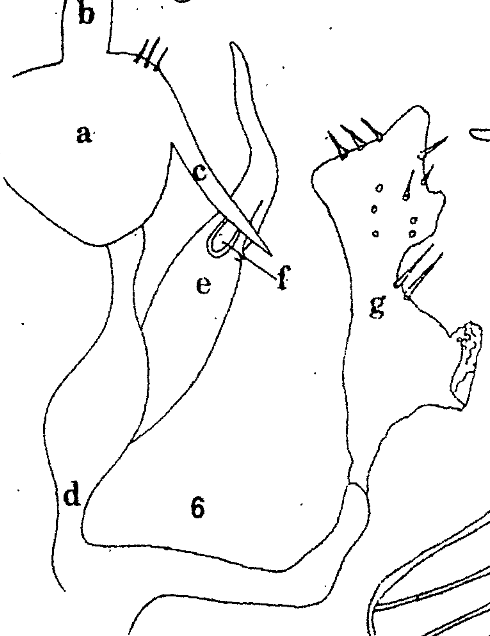

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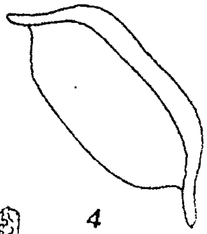

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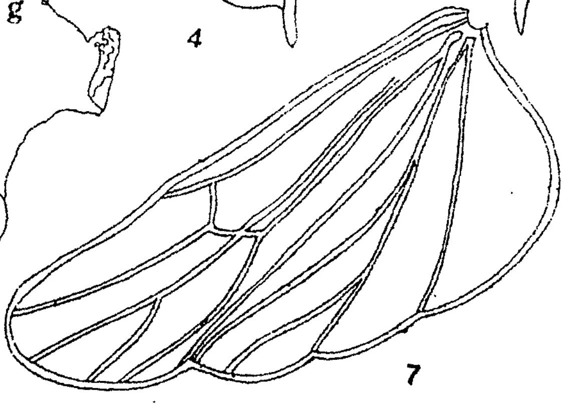

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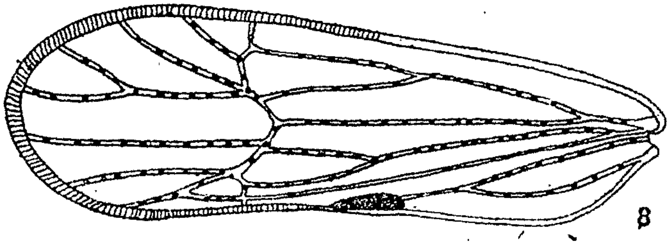

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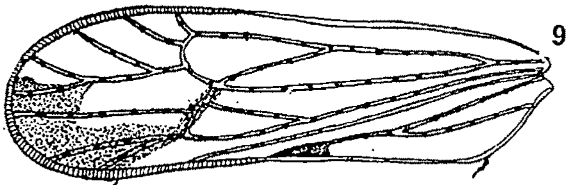
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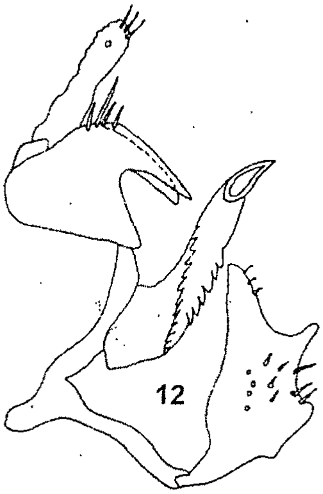
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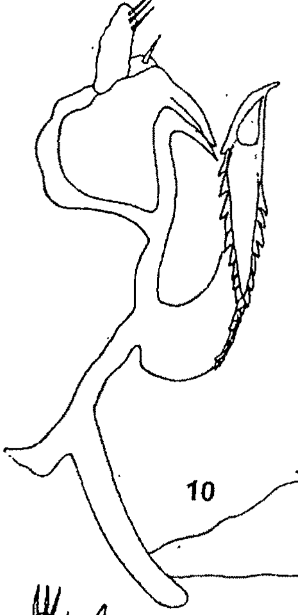
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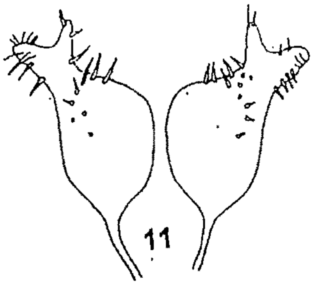
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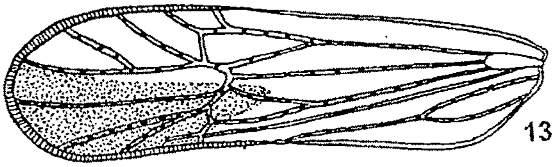
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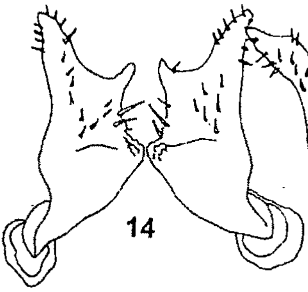
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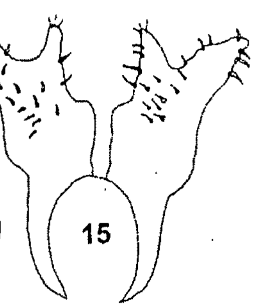
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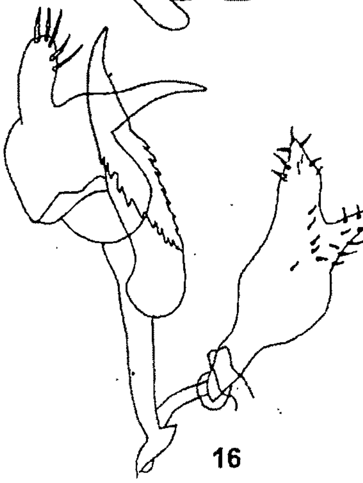
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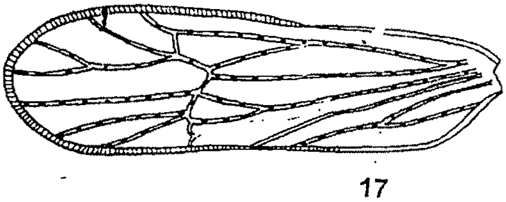
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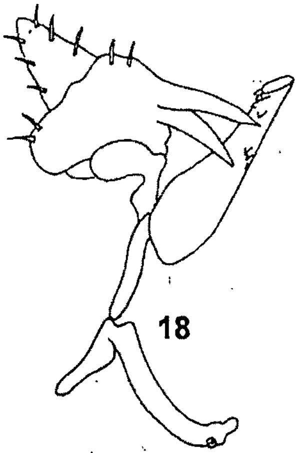
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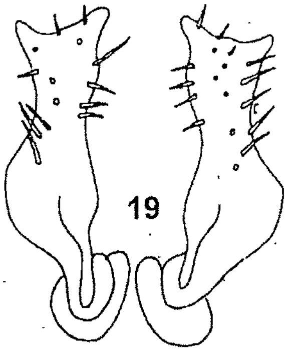
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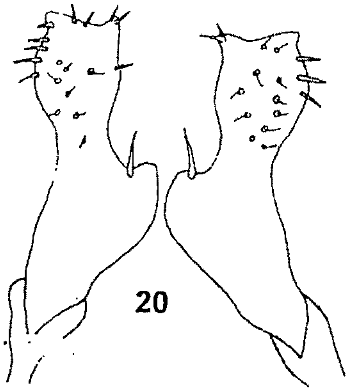
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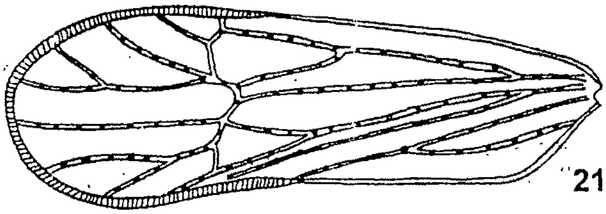
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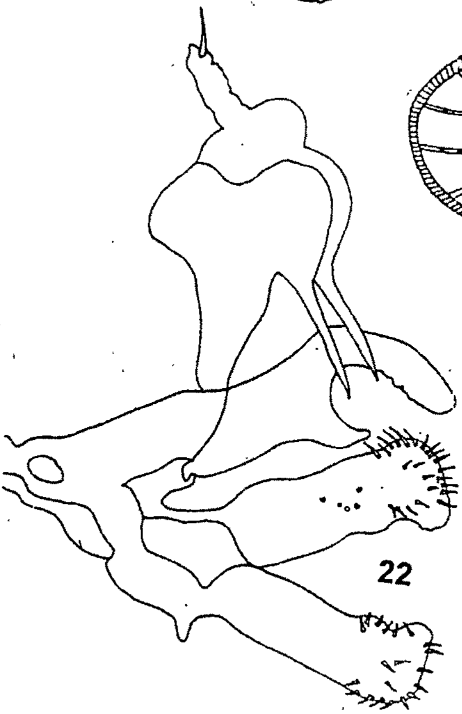
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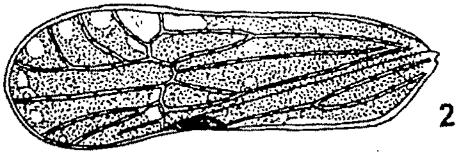
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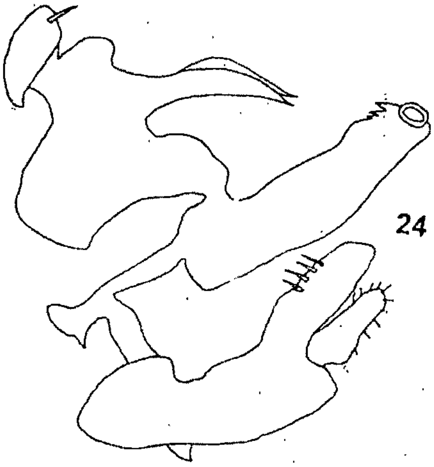
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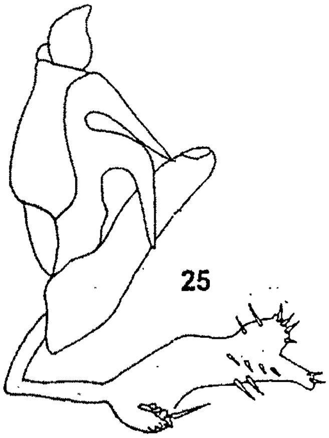

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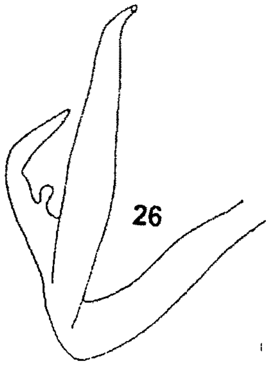

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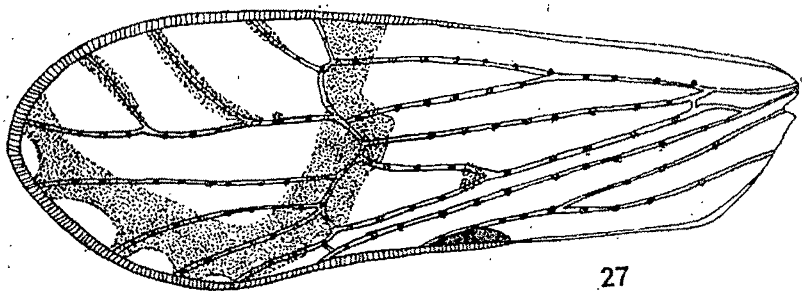

27

(1985) was followed to describe different body parts of a planthopper (Figs 1-8.).

RESULTS AND DISCUSSION

In the present investigation the following 10 planthoppers were identified from different rice ecosystems in coastal Andhra Pradesh in India.

1. *Nilaparvata lugens* (Stal)
2. *Sogatella furcifera* (Horvath)
3.* *Sogatella kolophon* (Kirkaldy)
4. **Sogatella vibix* (Haupt)
5. **Tagosodes pusanus* (Distant)
6. **Tethron albovittatum* (Matsumura)
7.* *Toya propinqua* (Fieber)
8. * *Harmailia anacharsis* (Fennah)
9. *Sardia rostrata* (Melichar)
10. * *Cemus* sp.

Among the above-mentioned species, the species marked by asterisk were recorded for the first time from Andhra Pradesh

KEY TO THE DELPHACID PLANTHOPPERS ASSOCIATED WITH RICE-ECOSYSTEMS OF ANDHRA PRADESH

1. Presence of one or more lateral spines on the basal segment of hind tarsus (Fig.3) .... *Nilaparvat lugens* (Stal)

-- Absence of one or more lateral spines on the basal segment of hind tarsus 2

2. Aedeagus twisted, tapering to apex with two rows of small teeth (Figs. 10, 12 & 16) . 3

-- Aedeagus tubular not twisted, without rows of small teeth (Fig. 26) 5

3. Tegmina with pterostigma; face with frons, clypeus, genae dark brown; genital styles strongly dialated at base, apex relatively small and almost equally bifurcated (Figs. 9,11) ... . *Sogatella furcifera* (Horvath)

-- Tegmina without pterostigma; face with frons, clypeus, genae not entirely dark brown; genital styles not as above (Figs. 13 & 17) 4

4. Face with frons, clypeus, genae entirely pale yellowish brown in colour; but genae dark brown in colour; genital styles flattened bifurcated with inner process very short and outer process long and gradually tapering to apex (Fig. 14) .... *Sogatella kolophon* (Kirkaldy)

-- Face with frons and clypeus pale yellowish brown in colour, but genae dark brown in colour; genital styles have the outer process of apical bifurcation dialating from base of middle then tapering to apex with dorsal margin forming a blunt angle (Fig. 15) .. *Sogatella vibix* (Haupt)

5. Frons with conspicuous raised pits on either side of the median carina; tegmina with black dots along veins, fuscous maculae apically (Fig.27) .... *Cemus sp.*

-- Frons without pits on either side of median carina; wings not as above 6

6. Aedeagus tubular and deeply curved (Fig. 22) .... *Tethron albovittatum* (Matsumura)

-- Aedeagus tubular and not deeply curved 7

7. Aedeagus tubular without teeth (Fig. 25) . ... *Harmalia anacharsis* Fennah

-- Aedeagus tubular with a few number of teeth (Figs. 18 & 24) 8

8. Aedeagus basally wider, gradually narrowed with 2-3 teeth like spines sub- apically; genital plates relatively flattened, trapezoidal shallowly bifurcated apically (Figs. 18 & 19) .... *Tagosodes pusanus* (Distant)

--- Aedeagus not narrowed gradually towards apically 9

9. Vertex narrow, elongated between longer compound eyes; tegmina dark in colour with pterostigma (Figs. 23 & 24)

.... *Sardia rostrata* (Melichar)

-- Vertex very short, shallowly excavated ; tegmina light stramineous in colour without pterostigma; genital styles flattened, broader, concave and wider in the middle with number of spines apically

.... *Toya propinqua* (Fieber)

Wilson and Claridge (1985) reported 25 delphacids on rice in major rice growing areas of the World. Wilson and O' Brien (1987) reported 22 delphacids on rice. Okada (1977) reported 20 species on rice as pests in Japan. Ishihara and Lowe (1969), Kalode (1983) and Misra (1980) reported four delphacids *viz., Nilaparvata lugens, Sogatella furcifera, Sardia rostrata* and *Unkanodes sapporonus* from India.

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Comparative Evaluation of Cooking and Drying Methods for Turmeric (*Curcuma longa*)

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ABSTRACT

A study was conducted to evaluate the performance of different boiling and drying methods, namely open sun drying on cemented floor, solar drying methods, namely open sun drying on cemented floor, solar drying (natural convection type) and mechanical drying of turmeric fingers of "Mydukur" variety cooked in closed vessel and autoclaving with water and with 0.1 per cent sodium carbonate (Na_2CO_3) solution. The quality parameters like moisture content, curcumin content, oleoresin per cent, non-volatile acetone extract yield and curcumin recovery by acetone extraction were estimated for turmeric fingers cooked with water and with 0.1 per cent sodium carbonate solution, dried by above methods. It was observed that the time taken for drying was minimum from mechanical drying followed by solar drying and open sun drying for both cooking methods. Fingers cooked with 0.1 per cent sodium carbonate solution yielded higher oleoresin per cent, curcumin recovery per cent by acetone extraction and non-volatile acetone extract (NVAE) yield compared to water cooked fingers for both cooking methods. The overall quality was found to be better in mechanical drying, followed by solar drying and open sun drying.

Key words : Closed Vessel Cooking, Drying of Turmeric, Sun Drying, Solar Drying, Mechanical Drying, Turmeric Quality

India is the world's largest producer and exporter of turmeric. During 2001-2002, India produced 6, 59, 000 tonnes of turmeric and exported 35, 000 tonnes valued at Rs.84.63 crores. The initial moisture content of fresh turmeric fingers ranges from 80 to 88% (wb), which are too high for their processing and storage. Therefore, reduction of moisture contents of turmeric to a level of 5-7% (wb) becomes necessary before their processing and storage.

In all the major turmeric producing states of India, drying is carried out during the winter months of December to March resulting in large quantitative and qualitative losses. Too slow rate of drying allows development of moulds and white spots appear once due to uneven heating and cooling. Traditionally, turmeric rhizomes are sun dried on mud floors, road side, etc. An improved method is therefore essential to reduce these losses.

Desikachar *et al.* (1959) have recommended the use of lime water or 0.05-0.1% solution of sodium bicarbonate or sodium carbonate to impart orange yellow tinge to the core of turmeric finger. Sampathu *et al.* (1988) dried turmeric finger by sun drying and mechanical drying and reported that colour retention was better in mechanically dried uncooked slices than the conventionally cooked and sun dried fingers. Similarly Krishnamurthy *et al.* (1975) reported that sun drying of slices gave a slightly surface bleached product compared to mechanically dried turmeric slices which were brighter in colour. Haribabu and Anand (1996) developed a tray dryer, using agriculture waste as heating medium can dry cooked rhizomes of turmeric which takes 58 hours to

Table 1 : Drying time and dry yield of turmeric fingers in different boiling and drying methods

Treatment	Drying method	Drying time (h)	Dry yield %
Closed vessel cooking with water	Sun drying	88.000	20.787
	Mechanical drying	32.667	19.367
	Solar drying	56.667	21.253
Closed vessel cooking with 0.1% Na_2CO_3 solution	Sun drying	88.000	19.047
	Mechanical drying	32.000	19.560
	Solar drying	57.333	19.580
Autoclaving with water	Sun drying	84.000	19.011
	Mechanical drying	30.670	19.663
	Solar drying	52.333	21.463
Autoclaving with 0.1% Na_2CO_3 solution	Sun drying	84.333	20.143
	Mechanical drying	31.000	19.560
	Solar drying	51.667	22.640

reach safe moisture level compared to 169 hours in open yard sun drying.

Therefore, this study to compare the efficacy of different drying methods of turmeric on quality parameters was under taken.

MATERIAL AND METHODS

Three different drying methods were used namely, open sun drying on cemented floor, solar drying (natural conventional type) and mechanical drying (Tray type). Water cooked and 0.1% sodium carbonate solution cooked turmeric fingers of "Mydukur" variety were used in drying methods. Turmeric fingers were cooked in closed vessel and autoclaved.

For conducting the experiments, fresh turmeric fingers of "Mydukur" variety were obtained from a farmer. The turmeric fingers were boiled in closed vessel and autoclaved with water and remaining half are boiled in closed vessel with 0.1% sodium carbonate solution. About 6 liters of water and 0.1% Na_2CO_3 solution were used for boiling of 2 kg of turmeric fingers and boiling time was 45 minutes for closed vessel and 15 minutes for autoclaving A horizontal autoclave was used for boiling of turmeric fingers at a pressure of 1.5 kg/cm^2.

Drying

Both water cooked and 0.1% Na_2CO_3 solution cooked turmeric fingers of 2 kg each were taken for all the drying methods. The turmeric fingers with an initial moisture content of 88% (wb) were dried to the final moisture content of 5-7% (wb).

Sun drying

The turmeric fingers were allowed to dry in the sun by spreading in 5-7 cm thick layers on drying floor. Spreading single layer is avoided to minimize the bleaching effects of sun. The time of drying was from 9 am to 3 pm. During night, the turmeric fingers were packed in polythene bags (gauge 200) which were moisture proof. The temperature of the ambient was noted after every 2 h with the help of a thermometer. All these experiments were replicated 3 times.

Solar drying

The solar dryer which was used for experimental study was designed and developed by SEED, Hyderabad. Both turmeric fingers cooked with water and with 0.1% Na_2CO_3 solution were spread on two different trays separately in a single layer in the solar cabinet dryer and allowed to dry. The essential environmental

Table 2 : Analysis of turmeric fingers subject to different boiling and drying methods

Treatments	Drying method	NVAE Yield*	Oleoresin %*	Curcumin*	
				Content	Recovery %
Closed vessel cooking with water	Sun drying	2.580	4.580	1.680	84.940
	Mechanical drying	3.130	4.743	2.023	84.400
	Solar drying	2.490	4.490	2.027	84.760
Closed vessel cooking with 0.1% Na_2CO_3 solution	Sun drying	2.990	4.660	1.550	80.900
	Mechanical drying	3.240	5.080	1.897	79.867
	Solar drying	2.600	4.763	1.980	80.230
Autoclaving with water	Sun drying	2.380	4.547	1.213	77.930
	Mechanical drying	3.600	4.733	1.523	76.630
	Solar drying	3.010	4.683	1.917	77.290
Autoclaving with water 0.1% Na_2CO_3 solution	Sun drying	2.920	4.630	1.073	75.320
	Mechanical drying	3.730	5.071	1.327	74.900
	Solar drying	3.240	4.743	1.523	75.100

* Moisture free basis

parameters like temperature and relative humidity inside and out side the solar dryer were measured after every 2 h along with total sunshine hours in a day. The moisture content of turmeric fingers was determined after every 6 h, till an optimum moisture content of 5-7% (wb) was obtained. Temperature gradient was also calculated. All these experiments were replicated three times.

Mechanical drying

The mechanical drying (tray type), which was used for the experimental study was designed and developed by C.M. Equipment, Bangalore. Turmeric fingers of 2 kg cooked with water at the initial moisture content of 88% (wb) were spread uniformly on a tray and were dried with heated air at 60±2°C. The moisture contents of turmeric fingers were determined after every 5 h till it attained an optimum moisture content of 5-7% (wb). Similar trials were also undertaken with turmeric fingers (2 kg) cooked with 0.1% Na_2CO_3 solution and all the experiments were replicated 3 times.

Quality Test Procedure

(i) Physical appearances in relation to boldness, shrivelling and surface colour were noted.

(ii) The dried fingers (about 400g) obtained from each of the samples were powdered to pass through 30 mesh sieve and were analysed for total colour content (as curcumin) by ASTA (1968) methods and for oleoresin by cold percolation method. In this method 30 g powder was packed in a glass column of internal diameter 3.2 cm and extracted with acetone giving an initial contact time of 2 h and subsequently 1 h. Totally, 5 extracts of 30 ml each were collected, pooled and analysed for non-volatile solids estimated according to the ASTA method for non-volatile ether extract. Curcumin in the pooled extract was estimated by evaporating 5 ml aliquots on a boiling water bath, suitably diluting the solids obtained with 95% ethyl alcohol and recording absorbance at 425 nm. The per cent recovery of curcumin by acetone extraction was calculated based on initial.

RESULTS AND DISCUSSION

Comparison of drying characteristics

The reduction in moisture content with reference to the time spent in sun drying, mechanical drying and solar drying is shown in Table1 for fingers cooked with water and

0.1% Na_2CO_3 solution. Open sun drying took the maximum time of 88 h, 84 h for both water cooked and 0.1% Na_2CO_3 solution with closed vessel cooked fingers and autoclaving, respectively, might be due to conduct of experiment in the month of March during which the prevalent ambient temperature varied 20-28ºC with a high relative humidity. This did not provide favourable conditions for rapid removal of moisture. Solar drier tools 56.6 h for the water cooked and 57.3 h for 0.1% Na_2CO_3 cooked fingers which were almost 37 per cent less than the sun drying and autoclaved fingers take 52h because the temperature inside the solar dryer was 8-20ºC higher and RH 10-30% less than the ambient, which provided favourable conditions for drying. Mechanical drying tools 32 h and 31 h for both water cooked and 0.1% Na_2CO_3 solution cooked fingers for closed vessel and autoclaved fingers respectively, which was 63.5% and 43.0% lesser than open sun drying and solar drying methods respectively, as the temperature was maintained at 60ºC in the mechanical dryer.

Physical appearance

Physical appearance of dried fingers obtained by different drying methods were compared. Sun and solar dried fingers were bold while tray dried samples were shrivelled in all the samples. This shrivelling may be attributed to the fast drying in tray drier.

Surface colour

Sun dried samples had an yellow surface while mechanical and solar dried sample had an orange yellow surface colour. The fading of colour in the sun dried sample can be ascribed to the photosensitive nature of curcumin.

Dry yields

The dry yield is almost 20% on moisture free basis which was comparable for all the drying methods of both closed vessel cooked and autoclaved fingers of turmeric.

Quality evaluation test

Curcumin content

The curcumin content of both water cooked and 0.1% Na_2CO_3 solution cooked turmeric fingers dried by different methods as estimated in terms of per cent and the results are presented in Table 2. The results indicate that water cooked fingers had higher curcumin contents compared to 0.1% Na_2CO_3 solution cooked fingers irrespective of cooking and drying methods. The drop in the curcumin content 0.1% Na_2CO_3 solution cooked fingers can be attributed to the destruction of curcumin in the presence of hot alkali, in conformity with Tonneson and Karlson (1985). Sun dried fingers had a lower curcumin contents compared to the corresponding solar and mechanical dried samples. The loss may be ascribed to the photosensitive nature of curcumin

Oleoresin and NVAE yields

The oleoresin and NVAE yields of both water cooked and 0.1% Na_2CO_3 solution cooked turmeric fingers dried by different methods as estimated in terms of % and the results are presented in Table 2. The water cooked fingers had lower oleoresin % compare to 0.1% Na_2CO_3 solution cooked fingers irrespective of drying methods. However, mechanical dried fingers had higher oleoresin per cent, followed by solar dried samples and sun dried fingers had least oleoresin per cent. The NVAE yield ranged from 2.490 to 3.730 per cent and followed a trend similar to that of oleoresin for both closed vessel cooking and autoclaving of turmeric fingers.

Curcumin recovery % by acetone extraction

The results are presented in Table 2. The curcumin recovery % by acetone extraction was higher in case of turmeric fingers cooked with water compared to cooked with 0.1% Na_2CO_3 solution irrespective of cooking and drying methods. The curcumin recovery percentage by acetone extraction was slightly higher for sun dried samples followed by solar dried samples and least in mechanical dried turmeric fingers. The lower curcumin recovery in mechanical dried turmeric fingers may be due to the more gelatinisation of starch which hinders the release of colouring matter during extraction.

It may be concluded that turmeric fingers cooked in 0.1% Na_2CO_3 solution with closed vessel cooking showed better effect in terms of higher oleoresin per cent, curcumin recovery per cent by acetone extraction and NVAE yield. The time required for drying was least by mechanical drying, followed by solar drying and sun drying irrespective of boiling methods. The quality (curcumin content, oleoresin % NVAE yield) of the mechanically dried fingers were superior, followed by solar drying and was poor in sun drying for both closed vessel cooking and autoclaved turmeric fingers.

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Combining Ability for Yield, Quality and Physiological Characters in Round Brinjal

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ABSTRACT

Combining ability analysis of a 10 x 10 diallel, excluding reciprocals was undertaken for fruit yield, yield components, quality and physiological characters in round brinjal. Non-additive gene action was noticed to be pre-ponderant for all the traits studied. A perusal of the *gca* effects revealed PLR 1 and JBPR 1 to be good general combiners for fruit yield and quality characters. Hence, these parents may be used in breeding programmes aimed at the development of high yielding and quality round brinjal hybrids. Among the hybrids, 14 crosses had exhibited significant and desirable *sca* effects for fruit yield per plant. Of these, nine crosses had recorded desirable *sca* effects in addition to high *per se* performance for the trait. An analysis of these crosses revealed the involvement of a good and a poor general combiner parent for majority of the crosses; and both good or both poor in few cases. The hybrid, PLR 1 x JBPR 1, involving both good combiner parents for fruit yield per plant, had recorded maximum fruit yield, in addition to desirable *sca* effects for fruit yield, earliness, dwarfness, total soluble sugars and total phenols. Hence, it is identified as a potential high yielding and quality round brinjal hybrid for commercial exploitation.

Key words : Combining Ability, Fruit Yield, Quality, Round Brinjal, Yield Components

Brinjal is one of the most common, highly productive and popular vegetable crops grown in India. It is quite popular as the poor man's crop and is widely cultivated in Gujarat, mostly in the rainy season. Improvement in the productivity levels of the crop is being attempted through the exploitation of hybrid vigour. Quality hybrids with high fruit drymatter and total soluble sugars in addition to low seed weight and total phenols are highly desired by the consumer. Further, the physiological growth parameters such as leaf area per plant have been reported to have a direct impact on fruit yield in brinjal (Chaudhary and Malhotra, 2000).

Crop improvement programmes aimed at the development of high yielding and quality hybrids require information on combining ability of the above traits, since it helps in the identification of superior parents with better *gca* and crosses with high *sca* effects. Knowledge on the nature of gene action governing the quantitative traits is also essential for planning systematic breeding programmes. In this context, the present investigation was undertaken to elucidate information on the nature of gene action and combining ability of round brinjal genotypes for fruit yield, yield components, quality and physiological characters, in addition to identification of suitable high yielding and quality round brinjal hybrids for cultivation during rainy season in Gujarat.

MATERIAL AND METHODS

The experimental material comprised ten elite homozygous lines of round brinjal, *viz.*, KS 224, JB 64-1-2, AB 98-10, AB 98-13, PLR 1, Gandhinagar Local, Bombay Gulabi, Morvi 4-2,

Table 1 : Combining ability ANOVA for fruit yield, yield components, quality and physiological characters in round brinjal

Source	d.f	Fruit yield per plant	Days to first picking	Plant height	Plant spread	1000-seed weight	Fruit drymatter	Total soluble sugars	Total phenols	Leaf area per plant
gca	9	0.91*	7.53**	408.40**	1611.98**	0.76**	1.05**	6.92**	0.007**	96504984**
sca	45	0.23**	5.77**	81.26**	587.33**	0.16	0.43**	6.90**	0.016**	55010832**
Error	108	0.03	0.07	17.69	47.88	0.11	0.01	0.001	0.000	240.19
σ^2gca		0.07	0.62	32.56	130.34	0.054	0.09	0.58	0.000	8042061
σ^2sca		0.20	5.70	63.57	539.45	0.055	0.42	6.90	0.010	55010591
σ^2gca/σ^2sca		0.35	0.11	0.51	0.24	0.98	0.21	0.08	0.000	0.15

** Significant at 1 per cent level

Surati Ravaiya and JBPR 1 obtained from the germplasm collections maintained at the Main Vegetable Research Station, Gujarat Agricultural University, Anand and their 45 hybrids derived from the 10 x 10 diallel mating (excluding reciprocals) of these lines. The hybrids and parents were evaluated along with the check, GBH 1 in a randomized block design with three replications for fruit yield; yield component characters, namely, days to first picking, plant height and plant spread; quality characters, namely, 100-seed weight, fruit drymatter, total soluble sugars and total phenols; and physiological character namely, leaf area per plant at the Main Vegetable Research Farm, Anand.

The sowings were undertaken in the nursery during the last week of July and transplanting of the seedlings was taken 35-40 days after sowing, depending on the growth of seedlings. The normal, healthy and vigorous seedlings of each genotype were transplanted in a single row plot of 6 m length, with inter-and intra-row spacing of 90 x 60 cm and the crop was raised following recommended package of practices.

Data were recorded on five random, competitive plants tagged for each entry, in each replication and the average values were computed. Observations for plant height and plant spread were recorded at last picking. In contrast, data on fruit yield per plant was obtained for each picking and the total was computed, while data on leaf area per plant were recorded at 90 DAT. The observations on fruit drymatter, total soluble sugars and total phenols were recorded on five random fresh fruits, taken from each genotype in each replication and the mean values were calculated. However, for 100-seed weight, five random mature fruits were taken for seed extraction and weighment. Further, observations on days to first picking were recorded on plot basis. Estimates of total soluble sugars and total phenols were obtained following the procedures by Dubois *et al.* (1956) and Malik and Singh (1980), respectively; and the values were computed utilizing the formula provided by Sadasivam and Manickam (1992). The estimates of combining ability variances and effects were obtained using Diallel analysis, Method 2 of Model I, suggested by Griffing (1956).

RESULTS AND DISCUSSION

The analysis of variance for combining ability (Table 1) revealed significant mean squares due to both *gca* and *sca* for fruit yield, yield components, quality and physiological

Table 2 : General combining ability effects of parents for fruit yield, yield components, quality and physiological characters in round brinjal

Source	Fruit yield per plant	Days to first picking	Plant height	Plant spread	1000-seed weight	Fruit drymatter	Total soluble sugars	Total phenols	Leaf area per plant
KS 224	-0.00	-0.76**	3.28**	-3.67	0.05	-0.36**	0.38**	0.01	-1225.27**
JB 64-1-2	0.00	0.18	0.99	-4.90*	0.00	0.35**	0.21**	-0.00	2321.49**
AB 98-10	-0.03	-0.76**	-3.82**	4.77**	-0.13	0.33**	-0.79**	-0.02	1789.56**
AB 98-13	0.23**	-0.76**	1.08	-0.90	-0.13	-0.16**	-1.13**	0.02	2357.66**
PLR 1	0.14**	0.40**	-11.43**	-22.81**	-0.41**	0.05	0.92**	-0.03*	-3686.85**
Gandhinagar local	-0.50**	0.98**	-1.48	-7.08**	-0.33**	0.32**	-1.18**	-0.02	-4381.19**
Bombay Gulabi	-0.16**	-0.18*	11.30**	0.34	0.20*	-0.37**	0.65**	-0.00	3330.18**
Morvi 4-2	-0.02	-0.76**	-3.30**	3.06	0.28**	-0.34**	0.13**	0.02	-2895.69**
Surati Ravaiya	-0.18**	1.06**	0.91	21.95**	0.30**	0.01	0.21**	0.03*	2091.70**
JBPR 1	0.54**	0.98**	2.47*	9.23**	0.16	0.17**	0.58**	-0.01	298.41**
SE (g_i) ±	0.04	0.08	1.19	1.96	0.09	0.04	0.01	0.03	4.38

*, ** Significant at 5 and 1 per cent levels, respectively

characters studied, with the exception of 1000-seed weight, indicating the importance of both additive and non-additive gene actions for these traits. Several workers had also reported similar results for fruit yield (Baig and Patil, 2002); days to first picking (Vaghasiya *et al.,* 2000); plant height (Baig and Patil, 2002); plant spread (Singh *et al.,* 1991); and leaf area per plant (Chaudhary and Malhotra, 2000). Non-additive gene action was however pre-ponderant for all the traits studied, indicating the need for heterosis breeding for improvement of these traits. The predominant role played by non-additive gene action in brinjal for fruit yield and majority of yield component characters has also been reported by Patil and Shinde (1989). Predominance of non-additive gene action for the quality traits studied namely, fruit drymatter (Kapadia, 1995), total soluble sugars and total phenols (Patel, 2003) has been reported earlier.

A perusal of the general combining ability (*GCA*) effects for parents (Table 2) revealed that none of the parents was good general combiner for all the characters studied. AB 98-13, PLR 1 and JBPR 1 were noticed to be good combiners for fruit yield per plant. Among these, PLR 1 was also noticed to be a good combiner for low seed weight, high total soluble sugars and low total phenols, while JBPR 1 was also observed to be a good combiner for fruit drymatter, total soluble sugars and leaf area per plant. Their hybrid, PLR 1 x JBPR 1, was also noticed to be a high yielding and quality hybrid. Hence, these parents may be used extensively in breeding programmes aimed at the development of high yielding and quality round brinjal hybrids. Further, KS 224, AB 98-10, AB 98-13, Bombay Gulabi and Morvi 4-2 for earliness; JB 64-1-2, AB 98-10 and Gandhinagar local for fruit drymatter; KS 224, JB 64-1-2, Bombay Gulabi, Morvi 4-2 and Surati Ravaiya for total soluble sugars; and JB 64-1-2, AB 98-10, AB 98-13, Bombay Gulabi and Surati Ravaiya for leaf area per plant were observed to be good combiners. These parents may be used

Table 3 : Specific combining ability effects of the hybrids for fruit yield, yield components, quality and physiological caharacters in round brinjal

Hybrids	Fruit yield per plant	Days to first picking	Plant height	Plant spread	1000-seed weight	Fruit drymatter	Total soluble sugars	Total phenols	Leaf area per plant
KS 224 x JB 64-1-2	0.24**	0.11	3.64*	-12.29**	0.06	-0.28**	7.37**	0.27**	-7331**
KS 224 x AB 98-10	0.01	0.69**	8.13**	11.95**	-0.02	-1.48**	-0.57**	0.00	-4435**
KS 224 x AB 98-13	-0.13	0.69**	-1.90	20.93**	-0.18	0.33**	-0.78**	-0.00	2643**
KS 224 x PLR 1	-0.29**	-0.46**	3.47*	18.81**	0.39**	0.21**	4.44**	0.01	11145**
KS 224 x Gandhinagar Local	-0.47**	-1.05**	-19.14**	-13.18**	0.34**	0.78**	-1.99**	0.13**	-1050**
KS 224 x Bombay Gulabi	1.02**	0.11	3.39*	24.48**	0.53**	0.64**	0.95**	-0.19**	-1182**
KS 224 x Morvi 4-2	-0.10	0.69**	9.20**	-28.47**	-0.30*	-0.48**	0.48**	0.05	3089**
KS 224 x Surati Raviya	-0.20**	-1.13**	7.42**	21.23**	-0.05	0.49**	-2.71**	-0.02	-2011**
KS 224 x JBPR 1	0.13	-1.05**	-8.33**	15.26**	0.30*	0.17**	-0.18**	-0.12**	4766**
JB 64-1-2 x AB 98-10	-0.06	0.11	1.08	12.35**	-0.17	1.21**	2.01**	0.08*	10020**
JB 64-1-2 x AB 98-13	0.52**	0.11	3.24*	-4.39	-0.14	-1.78**	-1.31**	0.12**	5656**
JB 64-1-2 x PLR 1	-0.65**	-1.05**	-1.16**	-40.05**	-0.75**	0.09	-3.83**	-0.03	-1256**
JB 64-1-2 x Gandhinagar Local	0.12	-1.63**	7.04**	31.44**	-0.20	-1.53**	-1.40**	-0.13**	10759**
JB 64-1-2 x Bomabay Gulabi	-0.16*	-0.46**	-4.31**	11.01**	0.08	0.69**	-2.90**	0.06	-5576**
JB 64-1-2 x Morvi 4-2	0.66**	0.11	6.39**	12.19**	0.10	0.39**	-2.92**	-0.16**	-2547**
JB 64-1-2 x Surati Ravaiya	0.09	-1.71**	10.99**	-4.26	0.38**	0.13**	-2.85**	-0.08*	2656**
JB 64-1-2 x JBPR 1	0.04	5.36**	3.58*	-9.73**	0.91**	0.01	-3.12**	-0.04	-4125**
AB 98-10 x AB 98-13	-0.44**	0.69**	4.40**	37.51**	0.53**	0.46**	2.42**	-0.07	2099**
AB 98-10 x PLR 1	-0.77**	-0.46**	-1.41	-1.37	-0.01	0.21**	-2.82**	0.24**	-5817**
AB 98-10 x Gandhinagar Local	0.16*	-1.05**	11.56**	30.89**	0.20	0.05	-0.20**	-0.14**	780**
AB 98-10 x Bombay Gulabi	-0.03	0.11	-5.08**	16.02**	-0.67**	-0.14**	0.33**	-0.10**	17506**
AB 98-10 x Morvi 4-2	0.13	0.69**	-5.68**	-15.19**	-0.35**	0.85**	1.11**	0.03	-2493**
AB 98-10 x Surai Ravaiya	0.51**	-1.13**	-11.39**	-33.71**	0.49**	0.33**	-1.17**	0.04	-2567**
AB 98-10 x JBPR 1	0.44**	-1.05**	4.97**	7.94**	-0.03	-0.69**	0.60**	0.04	-6319**
AB 98-10 x PLR 1	-0.34**	-0.46**	-6.68**	-24.92**	0.08	0.01	0.22**	-0.02	8388**
AB 98-10 x Gandhinagar Local	0.02	-1.05**	-10.54**	-33.19**	-0.42**	0.38**	-0.01	0.06	-1242**
AB 98-10 x Bombay Gulabi	0.87**	0.11	13.93	18.37**	0.42**	0.24**	-0.74**	-0.23**	-1775**
AB 98-13 x Morvi 4-2	-0.37**	0.69**	6.24**	22.29**	0.54**	-0.35**	-1.68**	0.23**	-9652**
AB 98-13 x Surati Ravaiya	-0.40**	-1.13**	-8.80**	8.53**	-0.03	0.28	1.36**	-0.01	-3940**
AB 98-13 x JBPR 1	0.67**	-1.05**	0.26	-17.27**	-0.26*	-0.10**	1.66**	-0.07	-347**
PLR 1 x Gandhinagar Local	0.57**	-2.21**	16.87**	8.82**	0.08	0.43**	-1.59**	0.03	2203**
PLR 1 x Bombay Gulabi	0.08	-1.05**	6.78**	12.29**	0.04	-0.53**	2.11**	-0.00	-6418**
PLR 1 x Morvi 4-2	0.77**	-0.46	1.66	53.23**	0.36**	-0.97**	0.69**	-0.10**	3803**
PLR 1 x Surati Ravaiya	-0.10	-2.30**	7.41**	14.57**	-0.48**	-0.16**	-0.45**	-0.10**	-6515**
PLR 1 x JBPR 1	0.85**	-2.21**	-6.61**	1.50	-0.25	-0.08	2.90**	-0.15**	-2647**
Gandhinagar Local x Bombay Gulabi	-0.26**	5.36**	-15.70**	-55.67**	-0.63**	-0.40**	-0.59**	0.04	-4171**
Gandhinagar Local x Morvi 4-2	0.33**	-1.05**	-11.52**	26.03**	-0.01	-1.07**	0.68**	-0.17**	1231**
Gandhinagar Local x Surati Ravaiya	0.07	-2.88**	9.82**	19.34**	0.20	-0.02	-1.35**	0.18**	-13727**
Gandhinagar Local x JBPR 1	-0.16*	-2.80**	-8.67**	-21.19**	0.16	-0.15**	3.10**	-0.14**	1280**
Bombay Gulabi x Morvi 4-2	-0.58**	0.11	-2.94	-6.39*	-0.09	1.62**	-1.44**	0.04	-6291**
Bombay Gulabi x Surati Ravaiya	-0.34**	-1.71**	11.36**	13.28**	-0.14	-0.15**	4.69**	0.04	-5314**
Bombay Gulabi x JBPR 1	-0.01	-1.63**	-6.99**	1.67	0.15	-0.01	0.95**	0.12**	311**
Morvi 4-2 x Surati Ravaiya	0.90**	-1.13**	13.37**	0.82	0.31**	-0.53**	2.70**	0.01	16881**
Morvi 4-2 x JBPR 1	-0.43**	-1.05**	-0.18	-22.81**	0.51**	0.07	-0.05**	0.20**	-6746**
Surati Ravaiya x JBPR 1	-0.08	-2.88**	3.18*	-5.37*	0.39**	0.25**	4.53**	-0.09*	22231**
SE (s_{ij}) ±	0.07	0.10	1.57	2.59	0.13	0.05	0.02	0.04	5.80

*, ** Significant at 5 and 1 per cent levels, respectively

in crop breeding programs aimed at improvement of the respective traits.

The study of specific combining ability effects (Table 3) revealed significant and desirable effects for several hybrids with regards to fruit yield, yield components, quality and physiological characters. Fourteen hybrids had exhibited significant and desirable *sca* effects for fruit yield per plant. Among these, only nine hybrids (KS 224 x Bombay Gualabi, JB 64-1-2 x AB 98-13, JB 64-1-2 x Morvi 4-2, AB 98-10 x JBPR 1, AB 98-13 x Bombay Gulabi, AB 98-13 x JBPR 1, PLR 1 x Morvi 4-2, PLR 1 x JBPR 1 and Morvi 4-2 x Surati Ravaiya) had recorded significant and desirable *sca* effects, coupled with high *per se* performance for fruit yield per plant. An analysis of the *gca* effects of the parents for these elite crosses with regards to fruit yield per plant revealed maximum number of elite hybrids to be of high x low type. The production of superior hybrids with the combination of high and low *gca* parents has also been reported by Chaudhary and Malhotra (2000). In few cases, crosses with both good general combiner parents (AB 98-13 x JBPR 1 and PLR 1 x JBPR1) had also exhibited high *sca* effects, indicating the role of additive x additive type of gene action and hence, a good scope for fixation of the heterotic effects through the isolation of high yielding homozygous lines in advance generations. Further, superior hybrids were also noticed to result with both poor combiner parents (KS 224 x Bombay Gulabi, JB 64-1-2 x Morvi 4-2 and Morvi 4-2 x Surati Ravaiya), indicating the presence of dominance x dominance type of gene action and their exploitation as hybrids only. Among the above hybrids, KS 224 x Bombay Gulabi, PLR 1 x Morvi 4-2 and PLR 1 x JBPR 1 hybrids had also recorded significant and desirable *sca* effects for both total soluble sugars and total phenols, important quality traits from the consumer and market view point. In addition, PLR 1 x JBPR 1 had exhibited significant and desirable *sca* effects for earliness and dwarfness. This hybrid had also recorded maximum fruit yield per plant and is therefore identified as a potential round brinjal hybrid for commercial exploitation.

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Genetic Divergence in Bhendi [*Abelmoschus esculentus* (L.) Moench] Genotypes

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ABSTRACT

Genetics divergence was estimated for 19 characters in 41 diverse genotypes using D^2 statistic. The genotypes recorded highly significant differences for all the characters studied and were grouped into 8 clusters based on relative magnitude of D^2 values. Among all the characters studied germination percentage contributed maximum towards genetic divergence followed by number of ridges per fruit, number of fruits per plant and number of seeds per fruit. The maximum intracluster distance was recorded by cluster II. The high intracluster distance indicated the presence of a wide genetic divergence among the genotypes belonging to same cluster. The genetically diverse genotypes from cluster II, VII and Cluster I, VI could be used in hybridization programme to produce superior recombinants and to create more genetic variability in bhendi.

Key words : Genetic Divergence, Bhendi

Bhendi [*Abelmoschus esculentus* (L.) Moench] which belonging to family Malvaceae is an often-cross pollinated crop. Genetic diversity has been considered as an essential pre-requisite for obtaining high yielding genotypes through hybridization. Despite its importance, no systemic amelioration on bhendi's genetic diversity was undertaken. Thus D^2 analysis is a sound tool in divulging the divergence among the genotypes based on multiple characters. It is, in general, found that the level of heterosis exhibited by a hybrid is a function of the genetic divergence between the parents. As a preliminary step of heterosis breeding, it is desirable to investigate the nature and degree of divergence among bhendi genotypes.

MATERIAL AND METHODS

The present investigation was carried out at orchard block of Agricultural College Farm, Bapatla during 2003-2004 using 41 genotypes in a randomized block design with three replications at inter-and intra-row spacing of 60 cm and 45 cm. Five plants were selected at random in each genotype per replication and data were recorded on germination percentage, plant height, number of branches per plant, number of nodes per plant, number of days for first fruit setting, number of ridges per fruit, fruit length, number of fruits per plant, fruit weight, fruit volume, number of seeds per fruit, 100 seed weight, longevity of tenderness, ascorbic acid content, yield per plant, shape index, YVMV incidence, powdery

Table 1 : Distribution of 41 bhendi genotypes in 8 clusters

Cluster	Number of genotypes	List of genotypes in the cluster
I	4	DOV-91-4, Pusa Sawani, VRO-5, VB-19
II	7	HRB-9-2, Pusa Makhmali, Parbhani Kranthi P-7, Srikakulam Local, 151-10-1,2 Red 151-10-1,2,3 Red
III	3	Dharwad Local, IC128089, VB-8
IV	6	Bapatla Local, EMS-8, HRB-55, IIVR-10, Modavasala Local, Punjab Padmini
V	3	Hybrid Ganga, IIVR-11, KS-410
VI	2	Arka Anamika, V-315
VII	11	Arabhavi Local, BO-2, Berhampur Local Cuttack Local, D-1-87-5, IC 45723 IC 128131, Lorm-1, VRO-6, Vijayawada Local, Vizianagaram Local
VIII	5	Gopalpur Local, IC 128080, Visakhapatnam Local, VB-20, VB-14

mildew incidence and cercospora leaf spot incidence. Genetic diversity between groups was estimated by using D^2 statistics by Mahalanobis (1936), following the procedure given by Rao (1952).

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences for all the 19 characters studied in 41 bhendi genotypes. The D^2 values (Table 1) between each pair of genotypes were estimated after confirming the differences in genotypes collected. Based on D^2 values, the genotypes were grouped in to 8 clusters. A wide range of variation was observed between D^2 values of genotypes. Among 8 clusters, cluster VII was the largest cluster comprising of 11 genotypes and cluster VI was the smallest comprising only 2 genotypes (Table 1).

Inter-and intra-cluster D^2 values were calculated using the procedure given by Singh and Choudhary (1977). The range observed for intra-cluster D^2 values was from 6.77 (Cluster V) to 12.348 (Cluster I). The inter-cluster D^2 values ranged from 8.340 (between cluster II and VII) to 92.540 (between cluster I and VI). The maximum inter-cluster values and minimum intra-cluster values indicated that the population groups were nearly homogeneous within and highly heterogeneous between clusters. Cluster I and VI followed by III and VI were separated by largest statistical distance of 9.620 and 9.606, respectively. Selection of parents from such clusters for hybridization would result in novel recombinants (Table 2). These results are in accordance with the findings of Varalakshmi *et al.* (1994), Rao *et al.* (2003) and Mukundalakshmi *et al.* (2003).

The results obtained on percentage contribution towards genetic divergence (Table 3) indicated that germination percentage (9.31%) contributed maximum towards divergence followed by number of ridges per fruit (8.61%), number of fruits per plant (7.86%), in tune with Parhi *et al.* (1993) and Hazra *et al.* (2002).

Table 2 : Inter- and intra-cluster average divergence (D^2 values) of 8 clusters for 19 characters estimated from 41 genotypes of bhendi

	I	II	III	IV	V	VI	VII	VIII
I	12.348 (3.514)	22.8 (4.775)	21.23 (4.608)	15.382 (3.922)	30.272 (5.502)	92.54 (9.62)	16.148 (4.052)	28.869 (5.373)
II		8.427 (2.903)	17.698 (4.207)	14.05 (3.748)	11.28 (3.359)	55.07 (7.421)	8.34 (2.888)	16.07 (4.009)
III			11.356 (3.370)	22.78 (4.773)	28.57 (5.345)	92.27 (9.606)	18.01 (4.244)	22.458 (4.739)
IV				11.03 (3.327)	16.38 (4.047)	67.19 (8.197)	11.66 (3.414)	15.29 (3.911)
V					6.77 (2.602)	52.72 (7.261)	15.23 (3.903)	15.52 (3.939)
VI						11.94 (3.455)	61.36 (7.833)	60.47 (7.776)
VII							9.02 (3.003)	10.85 (3.294)
VIII								8.74 (2.957)

Underlined figures are intra-cluster average divergence values; Figures inside parantheses are D-values

The cluster means for 41 genotypes for 19 characters (Table 4) showed that the mean values of the cluster varied in magnitude for all the nineteen characters While, the cluster VI recorded maximum values for germination percentage, number of branches per plant, number of nodes per plant, number of days for first fruit setting, number of ridges per fruit, fruit length, fruit weight, fruit volume, number of seeds per fruit, 100 seed weight, ascorbic acid content, yield per plant and shape index, cluster II for plant height, number of fruits per plant, longevity of tenderness and cluster I for YVMV incidence, powdery mildew incidence and cercospora leafspot incidence. The most important economic character, yield per plant was maximum for cluster VI (502.85 g) followed by cluster II (285.73 g), cluster I (278.52 g) and cluster VII (268.50 g). Thus clustering pattern helps in choosing parents for cross combinations that are likely to generate the highest variability for different characters which are economically important. Therefore, the genotypes in Cluster II and VII on one side and Cluster I and VI on the other side were highly divergent and could be utilized in heterosis breeding programme.

Table 3 : Contribution of different characters towards genetic divergence (D^2) in 41 geotypes of bhendi

Sl.No.	Character	Percentage Contribution towards divergence	Rank
1	Germination percentage	9.13	1
2	Plant height	5.90	9
3	Number of branches per plant	3.04	17
4	Number of nodes per plant	7.48	5
5	Number of days for first fruit setting (maturity)	4.76	13
6	Number of ridges per fruit	8.61	2
7	Fruit length	6.85	6
8	Number of fruits per plant	7.86	3
9	Fruit weight	6.23	7
10	Fruit volume	5.20	11
11	Number of seeds per fruit	7.59	4
12	100 seed weight	4.99	12
13	Longivity of tenderness (days)	5.51	10
14	Ascorbic acid content	3.10	16
15	Yield / plant	2.77	18
16	Shape index (1:b ratio)	6.20	8
17	YVMV incidence	3.74	14
18	Powdery mildew incidence	3.67	15
19	Cercospora leafspot incidence	2.54	19

Table 4 : Means of 8 clusters for 19 characters in bhendi

	Character/Cluster	I	II	III	IV	V	VI	VII	VIII
1	Germination percentage	79.17	94.29	70.00	91.67	93.33	100.00	90.91	78.67
2	Plant height (cm)	90.00	89.84	132.80	104.04	96.91	60.93	100.75	106.73
3	Number of branches per plant	0.95	1.57	1.56	1.62	1.06	3.11	1.83	1.28
4	Number of nodes per plant	23.59	19.66	22.95	19.20	21.93	24.59	21.25	21.67
5	Number of days for first fruit	45.11	45.79	44.82	45.93	44.98	42.26	44.40	46.31
6	Number of ridges per fruit	5.75	5.14	4.89	6.11	6.11	6.33	5.21	5.73
7	Fruit length (cm)	11.84	13.31	12.69	13.89	13.00	17.11	14.37	15.84
8	Number of fruits per plant	20.34	18.35	19.42	17.68	13.40	18.07	18.44	15.28
9	Fruit weight (g)	14.46	15.85	12.39	15.33	14.54	23.60	14.91	18.17
10	Fruit volume (cc)	8.24	13.36	9.01	6.66	17.18	18.25	12.97	11.62
11	Number of seeds per fruit	50.74	48.53	49.66	53.69	50.82	57.82	47.40	50.40
12	100 seed weight (g)	4.33	5.24	5.11	6.24	6.27	7.18	5.86	5.83
13	Longivity of tendemess (days)	4.66	5.28	5.63	5.34	4.91	5.21	4.69	4.77
14	Ascorbic acid content (mg)	9.28	10.34	10.47	10.60	11.59	13.99	6.87	8.23
15	Yield / plant (g)	278.52	285.73	223.62	263.64	261.54	502.85	268.50	237.43
16	Shape index (l:b ratio)	1.73	2.02	1.90	2.08	2.14	2.86	2.28	2.71
17	YVMV incidence (%)	50.16	22.38	49.61	38.68	17.33	5.07	35.19	44.85
18	Powdery mildew incidence (%)	54.40	23.42	28.62	48.19	23.95	13.22	39.47	30.60
19	Cercospora leafspot incidence(%)	54.96	22.06	19.10	47.69	31.19	12.01	38.25	27.33

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Performance Evaluation of Shallow Well SPV Pumping System

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ABSTRACT

The performance of SPV pumping system installed in a shallow well of 1.8 m diameter and 6.0 m depth was evaluated during 2001-2004 at College of Agricultural Engineering, Bapatla. The pumping system consists of a SPV array having 24 panels with 900 W rated capacity, a monoblock centrifugal pump of 1.1 hp. The water table depth in the well remained shallow in the range of 0.55 to 2.16 m and use of shallow well pump is justifiable in the sandy lps. The coversion efficiency of SPV array was found to vary from 3.0% to 11.4% for the temperature range of 28° to 43° C. The pumping efficiency was found to be in the range of 18.4% to 29.8%. In the field conditions SPV pumping system gave an average of 48.4 cum of water per day from the well. In order to pump this volume of water daily the energy requirement would come to 4-kilowatt hour. Hence, use of SPV pumping system can be encouraged in irrigation sector.

Key words : SPV Pumping System, Shallow Well, Conversion Efficiency, Pumping Efficiency

Due to ever increasing gap between demand and supply of energy for irrigation pumping, it is quite appropriate to search for alternate sources of energy. Solar energy if properly harnessed has huge potential to meet energy requirements in every sphere of life.

In irrigation sector, there are about 60 lakh pumpsets operated by diesel engines and 120 lakh operated by electric motors in our country. It cost about Rs.19,000 crores annually towards energy charges for operating these pumsets. In Andhra Pradesh, there are about 20 lakh pumsets exclusively operated by eletric motors. There is demand for electrification of over one lakh new pumpsets annually. At this rate the demand for energy is going to increase alarmingly in irrigation sector.

In the light of scarcity of diesel and a large part of farming area being remotely located, the Solar photovoltaic (SPV) pump is potential option with a decentralized source of energy. This can be directly installed at utility points and does not need long transmission lines. The Government of India has taken keen interest in promoting the use of non-conventional sources of energy. The Central Government through the Ministry for Non Conventional Energy Sources is giving more thrust for use of SPV pumping systems.

During sixties, photovoltaic solar system was successfully used in the remote, semiarid southeastern areas of the USSR for powering irrigation pumps (Lidorenko and Tamizheve, 1973). The US Department of Energy completed an experimental solar array system in 1977. The system was operated seasonally to run irrigation pumps, grain drying fans and for running other equipment (Pope, 1978). Between 1963 and 1973, 720 photovoltaic systems were installed in Japan with cumulative output of 13 KW. A part of the installed power was used for irrigation pumps (Rauschedach, 1980).

Yella Reddy and Gorantiwar (1977) have reported that solar radiation reaches its highest value in May and June (75 KWh / sq.m / day)

Table 1 : Pumping volume estimates of SPV pumping system for the period from 18-03-2004 to 22-04-2004

Day	Pumping volume, cu.m	Day	Pumping volume, cu.m
18-3-04	48.39	5-4-04	46.54
19-3-04	47.30	6-4-04	46.28
20-3-04	48.23	7-4-04	47.44
21-3-04	48.19	8-4-04	48.35
22-3-04	47.43	9-4-04	48.20
23-3-04	46.94	10-4-04	46.00
24-3-04	46.83	11-4-04	47.36
25-3-04	47.24	12-4-04	46.48
26-3-04	46.44	13-4-04	46.89
27-3-04	48.31	14-4-04	45.90
28-3-04	46.45	15-4-04	46.89
29-3-04	47.32	16-4-04	46.64
30-3-04	47.73	17-4-04	46.60
31-3-04	45.58	18-4-04	47.41
1-4--04	47.44	19-4-04	46.93
2-4-04	46.36	20-4-04	46.41
3-4-04	47.73	21-4-04	48.69
4-4-04	46.72	22-4-04	47.18
Average = 48.4 cu.m			

and the lowest value in January and December (40 KWh / sq.m / day) in the Delhi region. They also observed that the incoming solar light energy increases with time till 12.00 hours. After 12.00 hours it starts decreasing and found almost zero at 6.00 and 18.00 hours. The pumping efficiency and discharge were found to be increasing with total head upto head of 7m.

Doruvu Irrigation

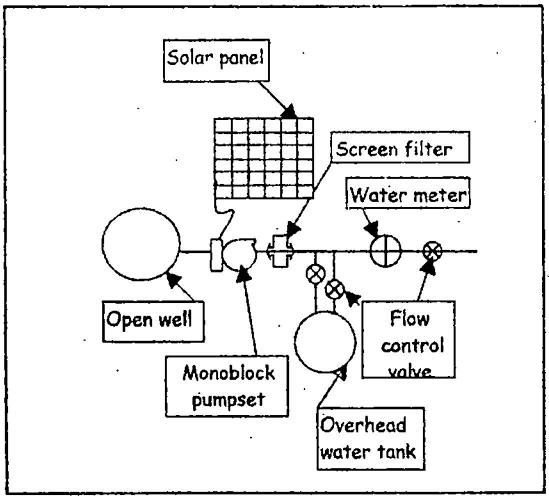
Andhra Pradesh has 974 km of coastline, mainly dotted with sandy coastal plains with width ranging from 1 to 10 km. Most of the coastal deltaic areas are irrigated by canal water; however, the farms very close to sea do not get enough water for irrigation since they are located at the tail end of the canals. Fortunately, the water table in these sandy tracts is generally shallow. In many places the water table rises to the ground level by the end of monsoon season and goes down a few meters during summer. The quality of water changes with the depth of water table. The fresh water floats on the salt water, hence one has to tap fresh water through shallow wells only; otherwise saltwater intrusion will take place. In order to avoid this problem the farmers use Doruvu Irrigation, with vey shallow open wells that look like ponds. The farmers dig ditches of about 3 to 4 m depth and 5 to 6 m diameter and place the dugout soil around the pond. To irrigate one acre, it is necessary to have 5 ponds in the field. Otherwise the farmer has to walk a long distance to cover the entire area. In this process about 10-15% of the cultivated area is lost to ponds and unavailable for cultivation. Hence, there lies necessity to provide better irrigation provision for the sandy tracts of coastal Andhra Pradesh.

By realizing the importance of ever growing demand of energy requirement in irrigation and also to provide an alternate to Doruvu irrigation, an attempt has been made to install and evaluate SPV pumping system in a shallow well at College of Agricultural Engineering, Bapatla.

Table 2 : Conversion efficiencies of SPV array at different temperatures

Temperature °C	Incoming Energy, Watts	Array output, Watts	Conversion efficiency, %
28	1775	200	11.39
29	2317	265	11.41
30	2832	280	9.76
31	4404	345	7.85
32	4057	3434	8.47
33	5920	380	6.15
34	5992	420	7.03
35	6033	422	6.99
36	6640	410	6.17
37	6540	405	5.98
38	4355	362	8.29
39	5050	385	7.60
40	6493	420	6.45
41	4855	394	8.10
42	5285	432	6.29
43	5520	410	7.43

Fig. 1 Layout of experimental setup showing SPV pumping system



MATERIAL AND METHODS

A shallow open well of 6m deep and 1.8 m diameter has been constructed with RCC rings of 1.8 m diameter and 30 cm height. The RCC rings were joined with cement mortar to make them leak proof to prevent sand cave in from sides. The experimental layout (Fig. 1) consists of a shallow open well, Solar Photo Voltaic (SPV) pumping system, overhead water tank, trickle equipment and other accessories. 900-Watt capacity SPV pumping system was purchased from Non-Conventional Energy Development Corporation of Andhra Pradesh (NEDCAP) and installed in the experimental field. The pump was fitted with 5 cm size suction and delivery lines. An overhead tank of 2000-liter capacity has been erected at 3.6 m height near by the open well in order to store excess water for subsequent use during off-time. Necessary valves were fixed in the delivery line for better control of the flow. A screen filter of 10-cum/hr capacity has been fitted in the delivery line to pump clean water to the irrigation system. A water meter was also fixed to note the quality of water pumped during the period of experiments. In the delivery line a hydrant was fixed to measure pump discharge regularly.

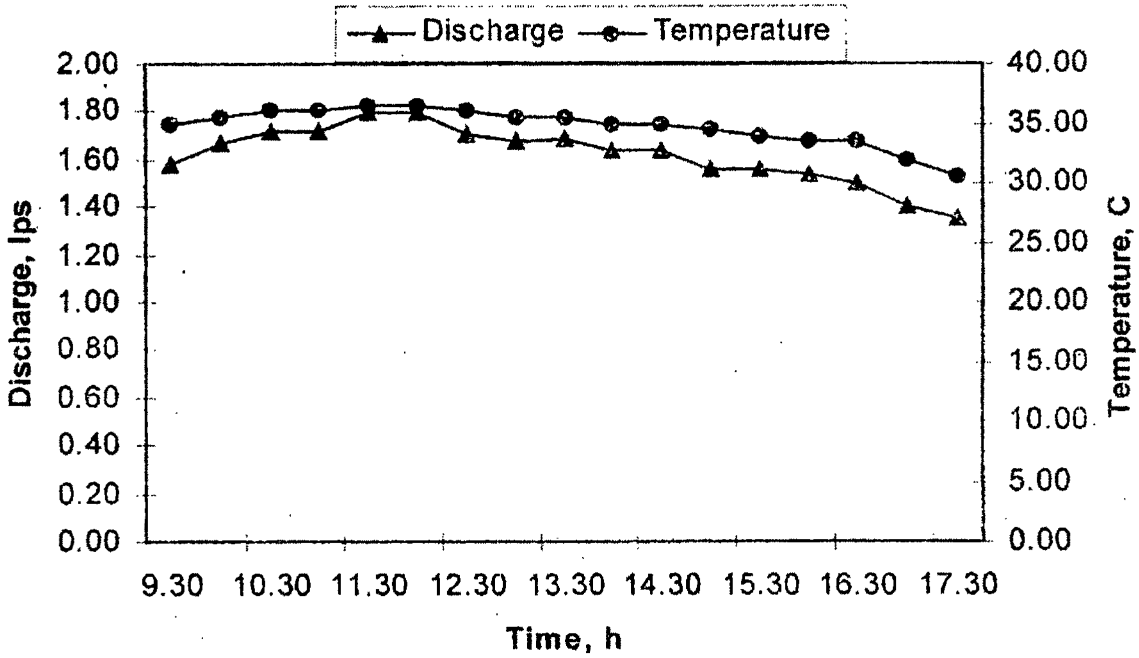
Details of SPV Pumping System

The solar water pumping system essentially consists of a SPV array directly powering a water pump. The techincal specifications of the SPV water pumping system installed are as presented.

Table 3 : Average values of SPV array output, discharge, and total head and pumping efficiency at various temperatures

S.No	Temperature, °C	Array output, Watt	Water table depth, m	Discharge, lps	Total head, m	Pumping efficiency, %
1	28	200	1.41	1.20	3.08	18.38
2	29	280	1.54	1.33	4.23	20.00
3	30	300	1.62	1.47	4.64	22.40
4	31	317.5	1.69	1.46	5.20	23.24
5	32	325	1.72	1.43	5.48	24.50
6	33	370	1.83	1.60	5.74	24.68
7	34	390	1.92	1.67	6.41	27.26
8	35	400	1.97	1.68	6.83	28.50
9	36	410	2.32	1.74	7.05	29.75

Fig. 2. Variation of SPV pumps discharge and temperature with respect to time on 09-05-2004

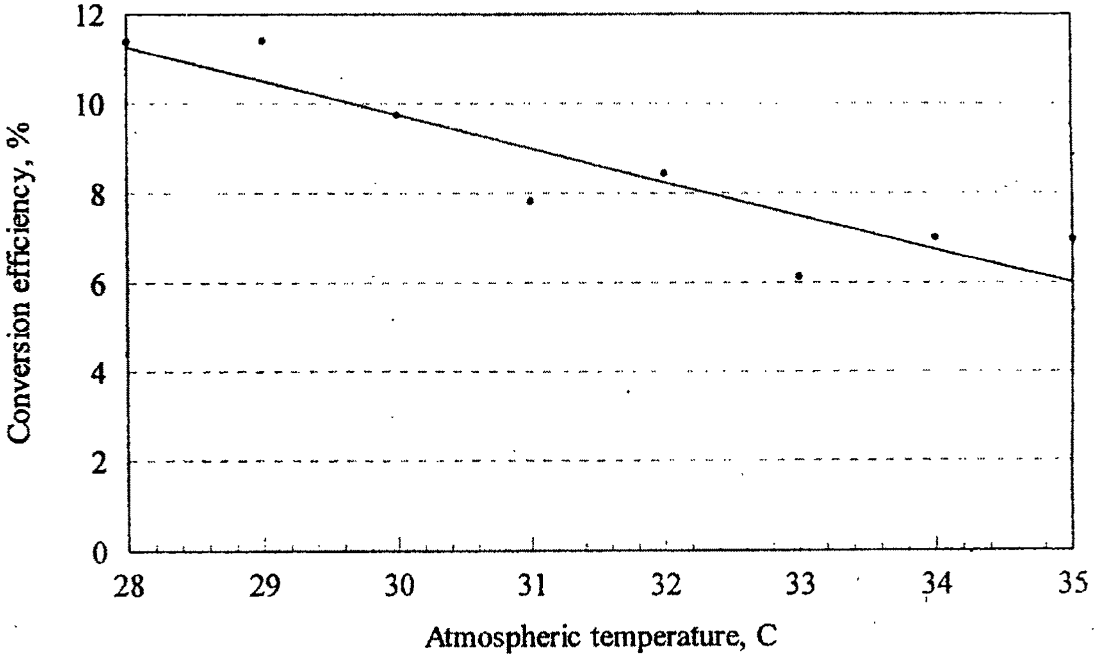


Model No. : SW 900
Type of motor pump set : DC surface
Rating of motor pump set : 1.10 hp
Maximum suction head : 7.0 m
Maximum total dynamic head : 15.0 m
SPV array output : 900 watt
Required shadow free area : 30 sq m
Water output : 70,000 lit/day at 10 m

RESULTS AND DISCUSSION

Data collected at hourly interval on temperature, incoming solar energy, water table depth, pump discharge and wind speed for over four years period has been systematically analyzed to develop some useful relations.

Fig. 3. Relationship between atmospheric temperature and conversion efficiency for the range of 28-35°C



SPV pump discharge

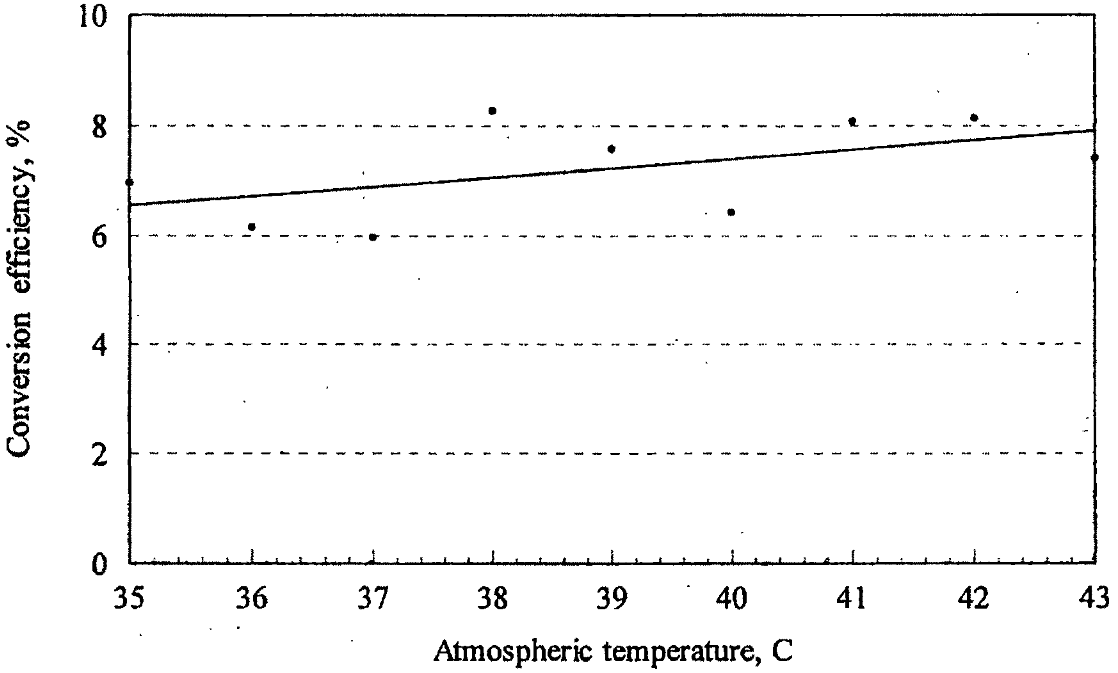
The pump discharge was determined by volumetric method by analyzing the time taken to fill 50 litre capacity tank at different periods during the experimentation. A sample presentation of pump discharge on 9/5/2004 from 9.30 A.M to 5.30 P.M has been systematically analyzed and shown graphically in Fig. 2. At 9.30 A.M. the discharge was found to be 1.58 lps and at 17.30 P.M. the discharge was 1.35 lps. The highest discharge of 1.79 lps was observed at 12.00 noon.

The trend indicates that the pump discharge is dependent on ambient temperature and found to increase with increase in temperature. This relation is due to fact that the solar array gives more output energy for higher temperature and that power is responsible for running the pumpset. In Fig 2, the area under the curve 'pump discharge versus time' gives the volume of water the pump delivered during the day and it was calculated by using Simpson method and found to be 56.1 cu m. Discharge estimates for the period from 18-03-04 to 22-04-2004 are calculated and shown in Table 1.

Water table depth

The average water table depth from the ground level calculated on weekly basis for the years 2001, 2002, 2003 and 2004. The variation in water table depth for the period from 2001 to 2004 indicates that the water table depth remained in the range of 0.55 m to 2.16 m. This indicates that the water table in the experimental site always remained shallow. Hence, shallow well pumps are suitable for pumping the water from the wells in the coastal areas located near Bapatla region.

Fig. 4. Relationship between atmospheric temperature and conversion efficiency for the range of 35-43°C



Performance evaluation of SPV pumping system

The data collected on temperature, incoming energy, array output, total head, pump discharge was analyzed and the conversion efficiency and pumping efficiencies were determined as detailed below.

$$\text{Conversion efficiency, } \eta_c = \frac{\text{Array output}}{\text{Total incoming energy}} \times 100 \quad \ldots (1)$$

$$\text{Incoming energy } (W/m^2) = 86.2069 \left[\frac{W/m^2}{mv} \right] \times 100 \times \text{pyranometer reading, } mv \quad \ldots (2)$$

$$\text{Panel area} = \text{Total number of cells} \times \text{area of each cell} \times \text{total number of modules} \quad \ldots (3)$$

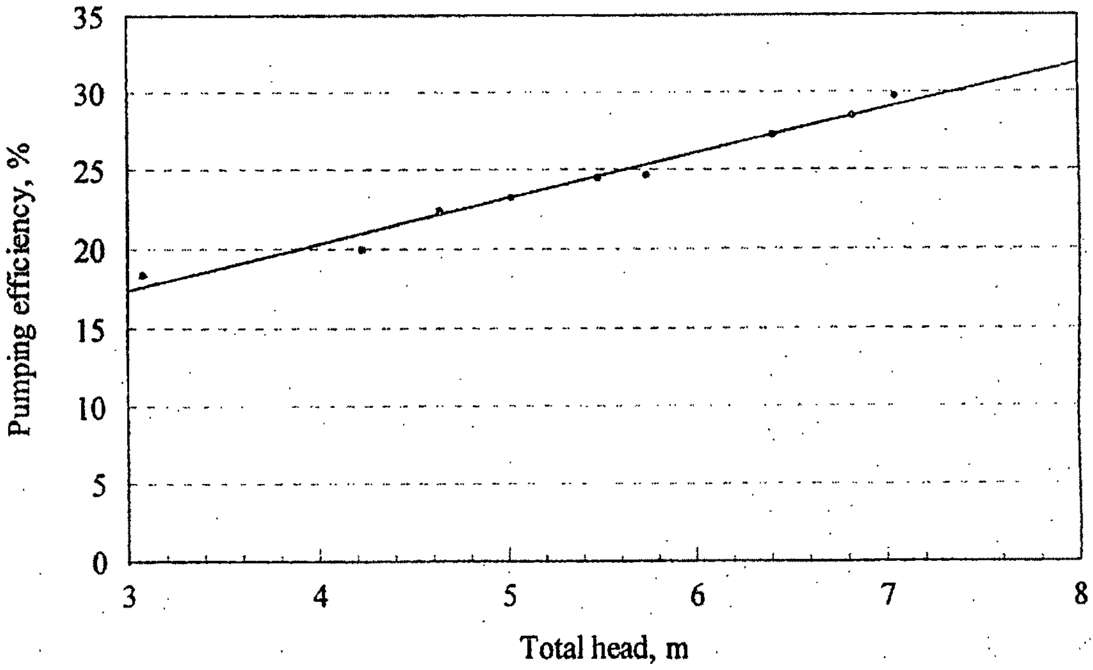
The panel area was found to be 6.8 m². Array output was read directly with the help of wattmeter in watts.

Coversion efficiency

Conversion efficiencies have been worked out from observations on incoming energy and array output. The average data obtained on incoming energy, SPV array output and the calculated conversion efficiencies at different temperatures are presented in the Table 2.

According to the results furnished in the table, there was no fixed relation between atmospheric temperature and conversion efficiency for the entire range of temperature between 28°C to 43°C. But by close observation, it can be seen that the conversion efficiencies decrease with increase in temperature initially up to 35°C and then increases from 35° to 43°C. In order to depict some useful relationship

Fig. 5. Effect of total head on pumping efficiency of SPV pumping system



between temperature and conversion efficiency separate graphs are plotted for the range of 28° to 35°C and 35° to 43°C.

The trend lines in Fig 3 and Fig 4 indicate general trend of the conversion efficiency with temperature and their relationships are as follows.

i) For temperature of 28° to 35°C

$\eta_c = -0.7489X + 32.225$ ....(4)

where, η_c = conversion efficiency,%

X = temperature, °C

a = 32.225 ; b = -0.7489

ii) For temperature range of 35° to 43°C

$\eta_c = 0.168X + 0.675$ ....(5)

where, η_c and X are as defined above

a = 0.675 ; b = 0.168

Pumping efficiency of SPV pumping system

From the data collected on array output, discharge and water table depth and as per the procedure total head and pumping efficiency were calculated and presented in Table 3.

A graphical presentation (Fig 5) was made between total head and pumping efficiency to study the effect on pumping efficiency.

It is seen that pumping efficiency increases as the total head increases. Highest pumping efficiency of 29.75% was found at 7.05 m total head and the lowest pumping efficiency of 18.38% was found at 3.08 m. the interrelationship between total head (H) and pumping efficiency is indicated through a straight line relation as shown below

$\eta_p = 2.8755H + 8.704$ ....(6)

where, ηp = pumping efficiency, %

H = Total head, m

This indicates that within the range of experimentation, increase in total head increases the pumping efficiency at the rate of 2.9% for every 1 m interval in total head.

Economic aspects

The solar pumpset costs about Rs.2.00 lakh and due to the government's subsidy to the tune of about ¾ of the system cost, it comes for Rs. 55,000. Assuming that the pumpset gives 1.5 lps average discharge during the day it costs about 4 kwh of energy per day. For one year it amounts to 1460 kwh. If the unit of electricity is charged at Rs. 3.00, it amounts Rs. 4380 towards electricity charges annually. Hence, use of SPV pumping systems for pumping of irrigation water is justifiable in view of ever increase in demand for energy in irrigation sector.

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Training Needs as Perceived by Extension Personnel Engaged in Transfer of Oilseeds Technology : A Diagnostic Study

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ABSTRACT

The study revealed that large majority of respondents were in middle age group and had graduate level of education. The training on oilseed crops underwent by all the experience categories were considered to be low. Majority of the respondents perceived that two years as interval between trainings with a duration of one week as ideal. Among the training needs perceived by the respondents, upgradation of skills in production technology of oilseeds ranked first followed by use of computers and multi media in extension programmes and recent trends in IPM which ranked II and III, respectively. The respondents also offered suggestions for organisation of training programmes effectively.

Key words : Training Needs, Transfer of Technology, Oilseeds

The present day agriculture has become more competitive, wherein the farming operations needs to be performed with more precision. Therefore, requires professional competency to cope up with the changing conditions in agricultural production and developments in general and oilseeds in particular for those engaged in transfer of oilseeds technology. Thus, the extension personnel engaged in transfer of oilseeds technology must be kept abreast of the latest developments in oilseeds through trainings, which improve the power of intelligence and develops desired attitudes and values required for their work. Eventually, the training depends upon the needs as perceived by the extension personnel. Keeping the training needs in view, a study was conducted with the objectives of knowing the profile characteristics of respondents engaged in transfer of oilseeds production technology and to assess the training needs and suggestions for effectiveness of training as perceived by the respondents.

MATERIAL AND METHODS

A total of 60 trainee participants of different states *viz.*, Andhra Pradesh (18 members), Karnataka (10), Maharashtra (7) and Tamil Nadu (25), who had undergone training on oilseed crops at Directorate of Oilseeds Research, National Plant Protection Training Institute and State Agriculture Management Extension Training Institute and direct contact formed the clientele of the study. A questionnaire developed for the purpose was administered during their stay at the various training institutes, besides direct contact at their working places. The data was collected, tabulated and analysed statistically.

RESULTS AND DISCUSSION

The respondents were grouped into different categories on the basis of personal characteristics. Frequency distribution of respondents on the basis of these characteristics is presented in Table 1.

Table 1 : Personnel characteristics of respondents

[N=60]

Particulars	Frequency	Percentage
1. Age : (years)		
Young (upto 35)	10	16.7
Middle (35 to 55)	45	75.0
Old(>55)	5	8.3
2. Education		
Matriculation / Intermediate	3	5.0
Graduation	50	83.3
Post Graduation and above	7	11.7

Table 2 : Distribution of respondents based on their service experience and training programmes attended

(N=60)

Category	Frequency	Percentage	No.of Training programmes attended (ave.)		Total
			Oilseeds	Others*	
Low experience (upto 10 years)	15	25.0	0.8[1]	4.1[4]	4.9[5]
Medium experience (10-20 years)	33	55.0	1.2[1]	6.7[7]	7.9[8]
High experience (>20 years)	12	20.0	3.9[4]	16.2[16]	20.1[20]

() indicates corrected to single digit * indicates other than oilseeds training

It is clear from the data that majority (75.00%) of the respondents were in the age group of between 35 to 55 years and 83.3 per cent of the respondents had graduate level education. It can be seen from the Table 2 that majority (55.00%) had put up medium service experience followed by the respondents (20.00) who had put up more than 20 years of experience. The mean number of trainings under went by this group was 8 times of which, one time in oilseeds as against 20 times and 4 times in oilseeds by the highly experience group. It could be informed that the trainings underwent in oilseed crops by them considered to be low and needs more number of trainings on latest technologies.

Further, the data from Table 3, indicated that majority (58.30%) had perceived two years interval between trainings followed by 25 % of the respondents preferred three years as interval between trainings, while one fourth of the respondents suggested three years as interval between training programmes. In case of duration of training, high majority (55%) of respondents perceived 'one week' duration as optimum, while 16.7% of respondents felt more than 'two weeks' was an ideal duration of training. Two years gap between trainings and one week duration of training were optimum for developing professional competency among the extension personnel engaged in transfer of technology.

The results on training needs presented in Table 4 indicated that vast majority (80.0%) of the respondents preferred upgradation of skills in production technology of oilseeds ranked first followed by use of computers and multimedia in extension programmes (71.7%), recent trends in integrated pest management in oilseed crops and recent trends in extension methodologies

Table 3 : Interval and duration of training as perceived by the extension personal (N=60)

Interval period	Frequency	Percentage	Duration of training	Frequency	%
One year	4	6.7	>one week	6	10.0
			one week	33	55.0
Two years	35	58.3	> two weeks	10	16.7
			Two weeks	6	10.0
Three years	15	25.0	>three weeks	5	8.3
Four years	6	10.0	-	-	-

Table 4 : Particulars of training needs as perceived by the extension personnel

Sl. No.	Particulars	Frequency	Percentage	Rank
1	Recent trends in extension methodologies for transfer of oilseeds technology	37	61.7	IV
2	Adoption behaviour and constraints analysis in oilseed crops	20	33.3	XI
3	Upgradation of skills in production technology of oilseed crops	48	80.0	I
4	Recent trends in Integrated Pest Management in oilseed crops	40	66.7	III
5	Economics and marketing of oilseeds including Post-harvest technology	35	58.3	V
6	Weed management in oilseed crops	22	36.7	X
7	Willing to media presentation on oilseed crops	25	41.7	VIII
8	Contingent planning for oilseed production for weather aberrations	33	55.00	VI
9	Use and maintenance of audio-visual aids in transfer of oilseeds technology	15	25.0	XII
10	Usage of agricultural implements in oilseed crops	15	25.0	XIII
11	Seed production technology in oilseed crops	28	46.7	VII
12	Indigenous technical knowledge usage for Participatory Technology Development	23	38.3	IX
13	Use of computers and multimedia in extension programmes	43	71.7	II

* Multiple response

for transfer of oilseeds technology ranked III and IV, respectively. The other training needs indicated by the respondents were also equally important for upgradation of extension skills in transfer of oilseeds technology.

It could be observed from the Table 5, that the suggestions offered by the respondents for effectiveness of training programmes were highly practical oriented with more number of field visits, ranked first followed by emphasis given to the appropriate technologies and information material made available before start of training programmes ranked II and III, respectively. The other suggestions were also good for strengthening the effectiveness of training programmes. It could be inferred that the suggestions offered by the respondents if considered by the training organisations would

Table 5 : Suggestions for effectiveness of training programmes as perceived by the extension personnel

Sl. No.	Particulars	Frequency*	Percentage	Rank
1	Highly practical oriented with more number of field visits	38	63.3	I
2	Emphasis given to the appropriate technologies	35	58.3	II
3	Avoidance of distance field visits	8	13.3	VII
4	Use of multimedia in the class room teaching	25	41.7	IV
5	Information materials made available before start of training programmes	30	50.0	III
6	More number of farmer participation in group meetings	14	23.3	V
7	Spot guidance to extension personnel as and when required	10	16.7	VI

* Multiple response

give considerable leverage in effective learning thereby improves capacity building among the extension personnel for effective transfer of technology.

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Extent of Adoption of Recommended Practices by Jute Growers of Nadia District of West Bengal

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ABSTRACT

It was observed that the ten independent variables namely education, land holding, material possession, extension contact, mass media exposure, socio-politico participation, risk orientation, scientific orientation, economic orientation, management orientation and knowledge had shown significant relationship with adoption at 1% level of significance with recommended practices in jute. The change proneness and market orientation were non-significant and value orientation was negatively significant with adoption at 5% level of significance.

Key words : Jute, Adoption, Recommended Practices

In India nearly four million small and marginal farm families are involved in jute farming. About 2.5 lakh workers are employed in jute industry and raw jute production as well as jute products. It generates paid employment to the secondary and tertiary sectors of the industry. Socio-economic importance of jute cultivation lies in the fact that it ensures job for sizable section of rural population, as it is a highly labour intensive crop.

There was a supreme demand of jute goods in India and abroad. India has exported 1.92 lakh bales of jute goods after fulfilling it's internal demand of 14.01 lakh bales in 2003-2004. So, jute production stood at total of 15.93 lakh bales in 2003-2004. In case of raw jute production, India produces 11.20 million bales in 2003-2004, but could not cross the last year's production of 11.37 million bales (2002-2003) as envisaged by Sen and Saha (2005).

The major pit falls of jute production may be the lack of knowledge of recommended package of practices and socio-economic characters of jute farmers which have got some effects on adoption of improved practices in jute cultivation. So the present study had been conducted with an objective to study the extent of adoption of recommended practices of jute farmers.

MATERIAL AND METHODS

The study was conducted in Nadia district of West Bengal purposively as it has the largest area under jute cultivation. Four blocks namely, Karimpur, Nakashipara, Tehatta and Chapra were selected as per their area under jute cultivation and one village from each of these blocks was selected randomly with a total sample of 120 farmers by selecting 30 farmers from each village. The data were collected through a structured interview schedule on various aspects

Table 1 : Distribution of farmers according to adoption n:120

S.No.	Category		Respondents	
			Frequency	Percentage
1	Low	(<15.47)	17	14.16
2	Medium	(15.48 to 18.99)	61	50.84
3	High	(>18.99)	42	35.00

Mean = 17.23 S.D. = 1.76

of the study. The farmers were individually interviewed. The data were analysed by using the statistical tools like mean, standard deviation, frequency, percentage, correlation and multiple linear regression.

RESULTS AND DISCUSSION

It was clear from the Table 1 that majority (50.84%) of the farmers possessed medium level of adoption followed by high (35.00%) and low (14.16%) level of adoption. It implied that most of the farmers had medium level of adoption. The possible reason for the finding might be that, most of the respondents had adopted the recommended practices of crop in general, which helped them to obtain more score. However, 14.16 per cent of respondents were still in the low adoption category, which indicates that more extension efforts were needed to improve the adoption level. These findings were in tune with the findings of Raja (2004).

An outer view of the Table 2, revealed that education was significantly associated with adoption. Education implied changes in behaviour, which favoured farmer's innovativeness. Similarly higher family education status favoured better exchange of ideas and easy decision making which greatly influenced the adoption behaviour may be the reason of this kind of relationship, as observed by Murmu (2003) and Sarkar *et al.* (2000).

Land holding of farmers had positive and significant relationship with their adoption, the more the land holdings, the more would be their adoption of practices. It required further explanation as land holding increase their potential for economic resources increase and they preferred to use more number of recommended practices in jute cultivation in order to increase their income and to further expand their lands. This would have been the reason for farmers with more land holding to adopt more number of recommended practices compared to farmers with less level of land holding as reported by Murmu (2003).

There was significant relationship between material possession and adoption. It implied that greater the material possession greater will be the adoption. Farmers having more number of material possession were well aware of benefit of the scientific innovations and competent enough to meet the cost of innovations which possibly favoured their adoption behaviour, in line with the findings of Das (2004).

Change proneness did not show any significant relationship with the adoption of farmers. Hence, it could be concluded that change proneness did not have any bearing on their adoption behaviour. Again it can be noticed

Table 2 : Relationship between selected independent variables and adoption of recommended practices in jute cultivation

n:120

S.No.	Independent variables	r-value
1	Education	0.48**
2	Land holding	0.55**
3	Material possession	0.41**
4	Change of proneness	0.10**
5	Extension contact	0.34**
6	Mass media exposure	0.33**
7	Socio-politico participation	0.41**
8	Risk orientation	0.24**
9	Scientific orientation	0.41**
10	Economic orientation	0.36**
11	Management orientation	0.21**
12	Value orientation	-0.20**
13	Market orientation	0.16NS
14	Knowledge	0.55**

NS = Non significant * Significant at 0.05 level of probability ** Significant at 0.01 level of probability

that even at higher or lower change of proneness the adoption level will be the same.

Extension contact of the farmer showed significant correlation with the adoption. This thereby showed that greater the extension contact, greater would be the adoption of recommended practices in jute cultivation. Because of this farmers approach to change agents like Agricultural Development Officer, Krishi Proyukti Sahayak, village extension workers etc. when they need solutions to problems in adopting the recommended practices in jute cultivation. Their extension contact caused more variation in their adoption levels, presenting this type of relationships, as reported by Murmu (2003).

Mass media exposure had significant relationship with the adoption of recommended practices. It implied that greater the mass media exposure greater will be the adoption, might be because of the farmers of the study area have used the mass media as the information source for getting new ideas regarding the practices in jute cultivation more than a media for entertainment, in accordance with Biswas (2002).

The socio-politico participation found to be significantly correlated with adoption. The significant relationship between socio-politico participation and adoption of farmers could be inferred that the adoption was the function of socio-politico participation, may be because farmers with more socio-politico participation might be concentrating on increased number of recommended practices in jute cultivation which results in more adoption levels to farmers with more socio-politico participation, as also reported

Table 3 : Multiple linear regression analysis of independent variables with adoption of recommended practices in jute cultivation n:120

S.No.	Independent variables	Regression coefficient	Standard error	't'-value
1.	Education	0.21	0.12	1.67 NS
2	Land holding	1.01	0.19	5.18*
3	Material possession	0.15	0.19	0.80 NS
4	Change proneness	-0.13	0.06	1.87 NS
5	Extension contact	0.01	0.06	0.25 NS
6	Mass media exposure	-0.23	0.13	1.76 NS
7	Socio-politico participation	0.17	0.08	2.12*
8	Risk orientation	-0.01	0.09	0.11 NS
9	Scientific orientation	0.18	0.10	1.69 NS
10	Economic orientation	0.07	0.10	0.75 NS
11	Management orientation	0.04	0.07	0.61 NS
12	Value orientation	-0.11	0.10	1.11 NS
13	Market orientation	0.02	0.13	0.19 NS
14	Knowledge	0.73	0.20	3.59*

F value = 14.009* $R^2 = 0.6513$ NS = Non significant *Significant at 0.05 level of probability

by Murmu (2003), Sarkar *et al.* (2000) and Roy (1993).

Risk orientation of the farmers showed a significant relationship with adoption. That implied greater the risk orientation, greater would be the adoption level, may be due to the fact that the farmers with high risk orientation might be having high level of adoption of innovations, since the crop cultivation call for drastic changes in practices sometimes. As some weather conditions were not routine in nature, they require risk taking ability as a condition to cause differential adoption under these conditions, which would have lead to significant relation between these two and Murmu (2003) reported the same.

Scientific orientation with adoption of recommended practices in jute showed a significant relationship, indicating that adoption was the function of scientific orientation of farmers. Normally, farmer with more scientific orientation would adopt more number of practices. The recommended practices and methods in jute crop require frequent change, leading to adoption of them in increasing fashion, as reported by Sridevi (2003).

There is a significant correlation of economic orientation with their adoption requires few mentions, as more profit orientation on the part of farmers would lead to more adoption of recommended practices to increase income. The farmers with more economic orientation might be trying to fulfil wish goals; namely children' s education, welfare and better standard of living, which require money and one of the means is to increase yields and income. The less economic oriented farmers, on the other hand might be maintaining level of adoption similar to the past, resulting in low adoption of recommended practices compared to high economic oriented farmers. This could be one of the reasons for differential adoptions, in high and low economic motivated farmers.

Management orientation had significant relationship with adoption of recommended practices of jute cultivation. It might be due to the fact that farmers oriented towards their farm know how to utilize their resources for efficient management practices. If the management orientation was greater, greater would be the adoption of new practices and he would be more oriented towards adoption, in conformity with Santra *et al.,* 2002.

Value orientation had negatively significant relationship with adoption of recommended practices in jute cultivation at 5% level of significance, which implied that adoption level would not change with the increase or decrease of value orientation. The plausible reason might be due to the fact that the high profit orientation over shadowed the values that they hold. They adopted innovation, which gave them more profit that had not been affected by their value orientation. The farmers of the study area had constant level of value orientation comes from their generation to generation as also reported by Roy (1993).

It could be clear that market orientation of the farmers did not show any significant relationship with the adoption. It implied that greater the market orientation, but there will be constant trend of adoption of the farmers because it depended on transport facilities. But it was a constraint for them. So they wanted to improve the quality of their produce to get higher price in local market. So that, they were aware of more recommended practices and wanted to adopt them. Therefore, market orientation had no bearing with adoption as reported by Roy (1993).

Knowledge of the farmers had shown a significant relationship with their adoption of improved practices. It may be concluded that higher the knowledge more could be the adoption of practices. Raja (2004) and Sridevi (2003) also reported that there was a significant association between knowledge and adoption. This might be due to the fact that as the level of information increases it pass a certain threshold, occur as more than the self generated pressure towards adoption. This might be the plausible reason that farmers with more knowledge will adopt more innovations than having less knowledge.

It was observed from the Table 3 that the thirteen independent variables with knowledge taken on multiple regression analysis gave the output value R^2 as 0.651. Hence, it could be inferred that independent variables put together to contribute 65.10 per cent in the variance of adoption of recommended practices in jute cultivation leaving the rest for extraneous effect. The independent variables like land holding, socio-politico participation and knowledge had contributed significantly at 5% level of significance towards the variation in the adoption of recommended practices.

The land holding, socio-politico participation and knowledge of farmers were the predictors of adoption of recommended practices of jute. Though these two independent variables are predictive of adoption, the other characteristics of farmers cannot be ignored because of their interaction effects.

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Debts Costed Life - An Unsuccessful Case Study

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ABSTRACT

The case study revealed the unsuccessfulness of a cultivator, the extent of failure for getting a good crop and what is expected of him and what he is not able to accomplish. Further because of maladies his economic conditions deteriorated, he was depressed, disinterested in life, frustrated and attempted suicide, costing life to escape from his responsibilities leaving back everyone to suffer. Further, emphasized on balanced thinking while taking decisions related to crop cultivation and creating awareness towards balanced debts.

Key words : Cotton, Debts, Case Study, Maladies, Remedies

Cotton suicidal deaths occurred in Guntur district of Andhra Pradesh due to obvious reasons, one significant reason being the heaping of debts at higher interest rates costing life to escape from the debts. This was analysed over a case study conducted in Thullur mandal of Guntur district with the respondents family about the suicidal cultivator named as Sri Jaya Rao.

MATERIAL AND METHODS

The method of exploring and analyzing the life of a social unit be it a person, a family, an institution or a community is known as a case study method. The case study techniques have shown steady trend towards formalization, now be conducted in manner that the data are amenable to quantification and statistical treatment and are indispensable for therapeutic and administrative purpose. This was conducted in harmony with the improvement suggested to the case study.

Case study research design was followed in the present study. Guntur district was selected purposively. Thullur mandal was selected because of the identity of the case and the specific reason being the higher use of plant protection chemicals. Further, the vulnerability of mandal towards suicidal deaths of cotton cultivators were demarcated by revenue authorities.

The data were collected primarily through informal discussions and interactions, coupled with semi-structured interview schedule which was used to avoid memory bias in eliciting information in the continuum from the family members of the deceased cultivators. Simple percentage and ranking were used for the analysis and interpretation of the data. Afterwards, it was coded, classified tabulated and subjected for statistical analysis and graphical representation.

RESULTS AND DISCUSSION

Sri Jaya Rao, an S.C cultivator, aged 55 years, educated upto 4th standard with joint family possessed 2 acres of dry land followed by a motor cycle and transistor, radio as material possession, with no farm profits. He had a leased land of 14 acres, which costed his energies and landed him into debts. Added to it, his elder son's right leg operation which cost him Rs.25,000 and cotton crop losses pushed him into tears. Further, his ambition of becoming a progressive cultivator was ended in dreams due to strained relations

Table 1 : Details of crops grown for last three years

Sl.No.	Item	Fist Year	Second Year	Third Year
1.	Crops grown	Cotton	Cotton	Cotton
2.	Expenditure incurred (Rs)	2,02,000	2,10,000	2,18,000
3.	Annual income (Rs)	2,17,600	1,44,000	93,600
4.	Net income (Rs)	+15,600	-66,000	-1,24,400
5.	Debts			
	a) Institutional (Rs)	35,000	3,150	3,150
	b) Private (Rs)	35,000	1,750	1,750
6.	Over dues after crop period (Rs)	-	1,35,600	2,56,500
7.	Over dues as on date	-	-	-
8.	Other expenditure incurred, if any (Rs)	50,000	50,000	75,000
9.	Net over dues (Rs)	**1,35,600**	**2,56,500**	**4,60,800**

A perusal of the Table 1 indicates the details of crops grown for the last three years, the expenditure incurred in all the three years, the decrease in the net income and also the losses experienced. The institutional and private debts taken, over dues after crop period and finally the net over dues as one date were also shown.

with his relatives, there by no cooperation from his near and dear made him psychologically depressed. With mounting debts, an auction notice from a bank caused him to consume pesticide and he committed suicide.

Critical maladies perceived by family members

It is special interest to begin with the observations about the cultivators maladies. **Psychological maladies** were sub-ranked as follows were fear-complex, loneliness, depression, sense of helplessness and hopelessness for future. **Family maladies** observed were operation of right leg of his son, no moral support, disputes with relatives, being the head of the family he has to bear the burden. **Social maladies** observed were unpredictable weather conditions like rains, cyclones, drought assumed first rank followed by lack of organizational effort of farmers in the community to aid group/ simultaneous action as may be necessary ranked second. **Support and service maladies** were high cost of fertilizers and chemicals, mounting debts, high rate of interest by private money lenders, non-availability of money in time, low price to farm produce, high labour charges beyond ones capacity assumed rank I, II, III, IV and V, respectively. Spurious pesticides, lack of quality control, lack of availability of labour in time, non-availability of irrigation followed them. **Technological maladies** were sub-ranked as given below with the figures in the parentheses indicating the rank. Lack of knowledge about optimum utilization of pesticides and fertilizers (I). Lack of awareness of hazards from wrong use of pesticides (II). Lack of realization of damages of mono cropping (III), Lack of knowledge about IPM practices (IV).

Counselling centres, AO- Technical support, Bank and Co-operative society - credit facilities, The government and the voluntary organization should concentrate more on propagating the prevention of suicides in cultivators through different media like television, radio, newspaper, exhibitions etc.and to implement emergency number 108 in all districts.

Balanced thinking while taking decisions related to cotton crop cultivation and creating awareness towards balanced debts followed by inculcating problem solving skills. Further,

Table 2 : Experience in Farming

Sl.No.	Item	Reponse
a)	Experience	8 years
b)	Investment	Rs.14000/ acre
c)	Number of acres	16 acres
d)	Commercial crops cultivated	Tobacco
e)	Investment on pesticides	Rs.5000
f)	Investment on fertilizers	Rs.2000

Table 2 expresses the fact that the farmer had an experiance of 8 years, invested Rs.14,000 per acre on the crop during the critical year on 16 acres of land. He had cultivated commercial crops like tobacco in the past. The expenditure incurred on pesticides and fertilizers was Rs.5000 and Rs.2000.

Table 4 : Rank order of maladies

Sl.No.	Item	Reponse
1	Psychological	I
2	Family	II
3	Social	III
4	Support and service	IV
5	Technological	V

The ranks as perceived by the case respondents were given in accordance with their preferences of maladies in the Table 3 as psychological denoted by Rank-I, Family with Rank II, Social Rank III, Support and sevice Rank IV, followed by Technological with least rank as Rank V.

Table 3 : Psychological maladies

Sl.No.	Item	Reponse
1	Previous suicidal attempts	No
2	Any one committed suicide	No
3	Relationships	Yes, the relationship was. broken with relatives
4	Change(s) in his eating habits	Yes, took very little food
5	Changes in his behaviour	Yes
6	Sense of hopelessness	Yes
7	Prone for anxiety A). Physically B) Mentally	Yes
8	Suffer from a) Guilt b) Worthlessness	Yes
9	Insecurity about his abilities	Yes
10	Depression	Yes
11	Inflexible and rigid	Yes

The results depicted in the above Table 3 is an indicative of cultivators psychological maladies like broken relationship with relatives, no awareness on suicides, took little food, change in behaviour, prone for anxiety, no hope for future, insecurity on abilities and became rigid.

correct season, timely sowing, maintenance of plant population, maximum principle results in maximization of profits and minimization of losses there by heaping debts will not result were the lessons learnt.

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Socio-Economic Status Scale

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ABSTRACT

With the advancement in empirical techniques in the field of social sciences in general and particularly in the area of research in Agricultural Extension Education, the question of measurement has become highly significant. The result of measurement is scale. The present study was designed to develop Socio-Economic Status (SES) scale for farm families. First, it was developed in Dharwad district of Karnataka and later the same was revised with the data collected from Rangareddy and Guntur districts of Andhra Pradesh by double stage proportionate random sampling. An objective scale was designed with a sample of 524 respondent farmers drawn from 24 randomly selected villages. The finalized scale included seven items *viz.*, occupation, landholding, education, socio-politico participation, possessions, house and house hold. Differential weightages were assigned to the various sub-items based on the mean scores of judges ratings where as the equal weightages were assigned to the main items of the scale. The scale score range is 1 to 35. The validity of the scale was established by using content, concurrent and construct validity. The test-retest method as well as inter judge reliability of the scale and the norms of distribution of SES scores were also established. The main items of the scale were cluster and factor analyzed through orthogonal rotation of axes. The scale bear testimony to the fact that there is a promise and on the basis of the norms thus developed, farm families can be classified into five socio-economic groups. It holds a great promise in the field of agricultural extension research as well as programme planning and policy making. It helps some of the financing agencies like banks to arrive at a proper scale of financial assistance to different categories of people in the villages. It can be used effectively by organizations and individuals in arriving at inferences on impact of change programmes in relations to vertical mobility of farm families. Thus, the study will provide to the extension workers, policy makers, administrators, sociologists, psychologists, officials of financing agencies, government agencies and post graduate students of agricultural extension education and allied branches, a tool for measuring SES of farm families.

Key words : Measurement, Scale, Socio, Economic, Status

Socio-economic status (SES) is generally considered an important variable, both in developmental programmes planning and in research in social sciences. With the advancement in empirical techniques in the field of social sciences in general and particularly in the area of research in agricultural extention education, the question of management has become highly significant. The result of such a measurement is a scale. No attempts were made to develop SES scale particularly in the changing situations in rural areas. Hence, the present study is designed and carried out to develop socio-economic status (SES) scale for farm families.

MATERIAL AND METHODS

Double stage stratified proportionate random sampling was followed. Data was collected from 524 farmers from 24 villages of Rangareddy and Guntur Districts of Andhra Pradesh Cluster and factor analysis was followed. Reliability and validity of the scale were calculated and norms were fixed.

Instructions for administration of socio-economic status scale

Investigators are expected to collect information from the head of the family. Put a tick mark (√) against the items and the following

Table 1 : Final format of socio-economic status scale

	Score
1. Occupation	
( ) No occupation	0
( ) Unskilled	1
( ) Semiskilled	2
( ) Skilled	3
( ) Farming/business	4
( ) Professional	5
2. Land holding	
( ) Land less (no land)	0
( ) Marginal (0.1 to 1.0 hectare)	1
( ) Small (1.1 to 2.0 hectare)	2
( ) Semi-medium (2.1 to 4.0 hectare)	3
( ) Medium (4.1 to 10.0 hectare)	4
( ) Large (10.0 + hectare)	5
3. Education	
( ) No schooling (illiterate)	0
( ) Functionally literate	1
( ) Primary school	2
( ) Middle school	3
( ) High school	4
( ) College	5
4. Socio-politico participation	
( ) Without any official position in socio-politico organizations	0
( ) Official position in one or more organizations	1
( ) Official position in social and political committee	2
( ) Financial contribution or raising fund for common work	3
( ) Active office bearer	4
( ) Involvement in community work	5
5. Possessions	
( ) None	0
( ) One farm animal (buffaloe, cow) / Bicycle / furniture, radio / phone	1
( ) Two farm animals/bullock cart/T.V/ computer	2
( ) Three to four farm animals/improved farm implement/newspaper/electricity	3
( ) Five to ten farm animals/gobargas plant/ pumpset/mobike	4
( ) More than ten farm animals/tractor/automobile	5
6. House	
( ) Shed thatched	1
( ) Mudwalled and thatched	2
( ) Brickwall and tiled	3
( ) Concrete house	4
( ) Concrete and double storied	5
7. House hold	
( ) Small (1 to 3 members)	1
( ) Medium (4 to 6 members)	2
( ) Large (7 to 9 members)	3
( ) Very large (9 + members)	4
( ) Special features	5
Village name	
Respondent name	

brief explanation may be of help in clarifying the doubts.

1 Occupation

It refers to primary family occupation or main source of livelihood. Unskilled occupations require no skill. He may be a casual labourer, watchman, or peon and maintains family on daily wages. Semiskilled occupations require little skill as in case of factory workers, laboratory attenders and persons involved in making leaf plates and mending of garments etc. Skilled occupations included carpentry, pottery, spinning and weaving, basket making, leatherwork etc. Barbers, carpenters, goldsmiths, mechanics and electricians come under this category. Farming refers to the individual cultivating a small piece of land which is leased by him. The holding may be less than two hectares, whereas business refers to merchant and or cultivation of ones own land below two hectares.

2 Land holding

It means the total area owned or cultivated by equating three acres of dry land to one acre of garden or one acre of wet land. The information about land holding may be obtained in terms of acres and changed to hectares through a conversion of one acre equal to 0.405 hectares.

3 Education

This relates of family head formal education. Illiterate (no schooling) does not know how to read and write. Functionally literate can read and write. Primary education is upto eighth

Table 2 : Score ranges of SES Categories

SES category		Score range
I	Upper SES	28-35
II	Upper middle SES	21-27
III	Middle SES	14-20
IV	Lower middle SES	7-13
V	Lower SES	1-6

standard in the school. Those who have passed eighth standard come under middle school level education. High school level of education is from eighth standard to tenth standard and this category also includes passing of secondary school leaving certificate (SSLC). College level education refers to graduates.

4 Socio-politico participation

Social participation includes many aspects, each of which is important to the community structure and change. It is the voluntary sharing in person to group and group-to-group relationships beyond the immediate household. It is interpreted as including both formal and informal group activities.

Politico participation refers to the participation in political organizations. It has been found that the politico participation is related to the degree of involvement one has in the social system. If any member of a family occupy official position in socio-politico organizations like village panchayat, political party, milk development board, co-operative society, youth club, farmers' forum, radio rural forum, commercial institutions, educational institutions, religious institutions, judiciary council and temple committee etc., it should be noted and score given accordingly. If any member of a family is an active office bearer of any socio-politico organization, it should also be scored accordingly.

5 Possessions

Farm animal may be bullock, buffaloe or cow. Radio includes transistors also. Newspaper under this category refers to daily or weekly that is subscribed. Mobike (motor cycle or scooter), pumpset, tractor, automobile (car/truck), gobargas plant and bullock cart should be owned by the family. Electricity refers to the electrical connection to the house. Improved farm implements include mould board plough, harrow, and cultivator etc. Possession of each should be noted down and score given accordingly.

6 House

Shed thatched is usually a one-room construction with a thatched roof. A construction with more than one room with mud walls and a thatched roof may come under "mud walled and thatched" category. Brick wall and tiled house refers to a construction with brick walls and tiled roof. Concrete house is one which is built with a foundation, using stone or bricks with mortar and cement and having a concrete roof. Concrete and double storied is unusually large house, containing more than five rooms and having more than one storey.

7 Household

The total number of members in the household has to be noted down and score given accordingly. Any special features of the household in relation to socio-politico participation, occupation and education due to which the status of the family is considered high, should be ascertained and score given accordingly.

RESULTS AND DISCUSSION

The present study provides to the extension functionaries, policy makers, administrators, sociologists, psychologists, economists, government officials, a scale for providing SES information for effective implementation of ongoing agricultural development programmes.

Scoring

There are seven main items *viz.*, occupation, land holding, education, socio-politico participation, possessions, house and household (Table 1). The farmer is given a score under each of these seven categories so that the final socio-economic status index is considered under each category. Only the maximum possible score is considered under each category. The score, of course, depends upon the weightage of the item. For instance, under fifth category "possessions", the farmer may possess one farm animal as well as a radio, and no other possessions. One farm animal has a weight of one, and radio has a weight of two, so the farmers score under this category is two. Eventually the scores of all seven categories are added and this represents the socio-economic status index.

The range of scores on the developed SES scale is between 1 to 35 (Table 2). On the basis of the scores, farmers can be classified into five SES categories as given below.

In nut shell, socio-economic status (SES) is an important variable in the field of rural sociology, agricultural economics, psychology etc., but also in extension education. Several attempts were made to develop SES both out side and within the country but have not adequately served the purpose. Hence, the present scale can be supposed to be more improved and more scientifically developed in the field of social sciences. Infact, it is a radical departure from the traditional methods of measuring SES of farm families.

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Economics of Redgram Processing in Prakasam District of Andhra Pradesh

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ABSTRACT

Investment cost on machinery was worked out to Rs. 5,10,000 constituting 56 per cent in total investment. Raw material cost was the major cost in variable cost. Dal mills are running sucessfully on profitable lines. The breakeven output was estimated at 11,249.96 quintal and margin of safety was 11, 250.04 quintal.

Key words : Economics, Redgram, Processing

Agro-processing industry is defined as " one which process biomass i.e. agricultural raw material, which include ground and tree crop as well as livestock and fisheries, to create easily exportable forms, enhances nutritive value for and extract chemicals for other uses". Andhra Pradesh is predominantly an agricultural state endowed with abundant natural resources and a wealth of traditional skills in production. Among the major agro-industries dal mills contribute a major portion. There was a general practice of processing raw material by private mills and 90 per cent of raw material was processed by this system in Andhra Pradesah (Technical Commitee report, 1988). Therefore, it becomes important to assess the extent of economic aspects of processing units and to identify the problems that are encountered by millers. The objectives of the study are, to estmate the investiment pattern for establishing a dal mill, to work out the costs and returns of selected dal mills and to study breakeven analysis for selected dal mills.

MATERIAL AND METHODS

In Andhra Pradseh, Prakasam district was puposively selected for this study because more number fof processing units are concentrated in this district. There is no dearth of raw material availability and market for dal. In this district, Yerragondapalem mandal was selected purposively because it has large number of dal mills. A sample of three dal mills were selected randomly from total. Primary data was collected with pretested schedule from dal mill owners. Required secondary data was collected from District Industries Corporation.

The data thus collected were subjected to tabular, breakeven analysis.

1. Investment, costs and returns were calculated by using available information.
2. Breakeven output was calculated by using this formula

$$x = f/p-v$$

x = Breakeven volume of rice mill in quintals
f = Fixed cost per unit (Rs.)
v = Variable cost per unit (Rs.)
p = Price per unit (Rs.)

RESULTS AND DISCUSSION

Total investment in dal mill was Rs. 9,10,000. The investment cost on buildings was Rs. 4,00,000 and on machinery it worked

Table 1 : Investments on buildings and machinery for dal mill

S.No.	Particulars	Amount (Rs.)	Per cent in total
1	Investment on buildings	4,00,000	43.95
2	Investment on machinery	5,10,000	56.05
3	Total investment on fixed assets	9,10,000	100.00
4	Investment on buildings per quintal	88.88	-
5	Investment on machinery per quintal	113.33	-
6	Total fixed investment per quintal	202.21	-

Table 2 : Processing costs (Rupees per quintal of output) in dal mill

S.No.	Particulars	Amount (Rs.)	Per cent in total
a) Variable costs			
1.	Cost of raw material	2325.51	89.22
2.	Cost of gunny bags	20.10	0.77
3.	Transport charges	21.95	0.84
4.	Incidental charges	1.16	0.04
5.	Hamali charges	3.04	0.11
6.	Power charges	4.10	0.15
7.	Repair and maintainance	1.76	0.06
8.	Interest on working capital	167.96	6.44
9.	Taxes	58.19	2.23
	Total variable costs	2603.37	99.83
b) Fixed costs			
1.	Depreciation		
	i) on building	0.26	0.09
	ii) one machinery	0.76	0.02
2.	Salaries for permanent staff	1.50	0.05
3.	Interest on fixed capital	0.31	0.01
	Total fixed costs	2.83	0.17
	Total costs (a+b)	2606.2	100

out to Rs. 5,10,000 constituting 43.95 per cent and 56.05 per cent respectively to the total investment cost. However the cost per quintal incurred on buildings and machinery was quite low amounting to Rs. 88.88 and Rs. 113.33 respectively.

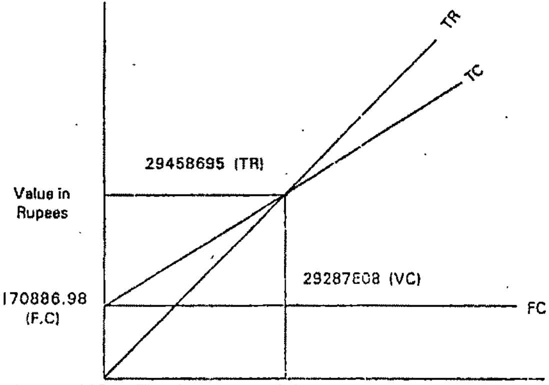
Coming to total cost incurred to produce one quintal of dal was Rs. 2,606.20, of this the variable cost amounted to Rs. 2,603.37 which accurated for 99.83 per cent of total cost. The fixed costs amounted to Rs. 2.83 comes to 0.17 per cent of the total costs. The raw material (redgram) which alone amounted to Rs. 2,325.51 per quintal and accounted for 89.22 per cent in total costs. Next important variable cost was the interest on working capital which accounted to Rs. 167.96 per quintal and amounted for 6.44 per cent of total cost. The other, important items are cost of gunny bags (Rs. 20.10), transport charges (Rs. 21.95 per quintal), Taxes (Rs. 58.19) which amounted for 0.77 per cent 0.84 per cent and 2.23 per cent of total costs respectively. Other items included in fixed costs are depreciation charges on buildings and machinery amounted for major costs.

Storage cost incurred per quintal of dal was Rs. 20.53 of which 97 per cent of cost was towards gunny bags and the rest of the cost was

Table 3 : Gross returns in dal mill

S.No.	Particulars	Quantity (qunitals)	Value (Rs. Lakhs)
A.	Mill Products		
	1. Dal	22,500	589.17 (97.03
B.	By-products		
	1. Husk	5986	18.00 (2.97)
	Total quantity milled	30,000	
	Total returns		607.17
	Total returns per quintal of dal		2698.56

Fig. : Breakeven outplut in dal mills



Note : TR = Total revenue (q)
TC = Total cost (Rs.)
FC = Fixed cost (Rs.)

Table 4 : Net return in dal mill

S.No.	Particulars	Amout (Rs.)
1.	Total returns (per quintal of dal)	2698.56
2.	Total Costs (per quintal of dal)	2626.73
3.	Net returns (per quintal of dal)	71.83

shared between depreiciation on godown (Rs. 0.13), repair charges of godown (Rs. 0.20), depreciation charges on tarpaulin (Rs. 0.12) and cost of chemicals (Rs. 0.08).

Gross returns obtained from the dal mill through the sale of the main product *i.e.* dal and by-product *i.e.* husk were estimated shown in the Table 3. It is observed that on average the dal mill milled nearly 30,000 quintals of redgram kernels and obtained 22,500 quintal of dal valued at Rs. 589.17 lakhs and 5986 quintals of husk valued at Rs. 18 lakhs. The total cost and net returns per quintal of dal was produced is evaluated in the Table 4. The net returns realised over the total cost of processing amounted to Rs. 71.83 per quintal of dal. The gross returns and processing cost per quintal were in the order of Rs. 2698.56 and Rs. 2626.73. This reveals that dal mills are running successfully on profitable lines.

The breakeven volume of dal mill was 11,249.96 quintals, where as the actual production was double the breakeven output (Fig). This margin of safety shows that the dal mills are operating above the capacity utilisation. On an average dal mill processes nearly 30000 quintals of redgram kernals and recovers 22,500 quintal of dal. The recovery percentage is 75.

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Impact of Cattle Development Programmes : An Assessment in the Context of Andhra Pradesh

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ABSTRACT

Key Village Scheme had its growth-impact of decrease in key village centres and increase in artificial insemination units. A multi-faceted approach to all aspects of cattle development and marketing (1971-72) provides good breeding facilities by introducing superior bulls. Intensive Cattle Development Project envisaged a significant increase in the artificial inseminations, thus, a break through in milk production.

Key words : Cattle Development Programme, Livestock Farming, KVS, KDP

Animal husbandry is an important sector of the economy in both temperate and tropical regions of the world. India has one of the largest livestock populations (22 %) in the world, which consists of buffalo (55 %), goat (20 %) and cattle (16 %) (FAO, 1998). Livestock sector contributes significantly to the economy of the country and has great potential for employment generation, particularly, in rural areas.

As per the income estimates of 1992-93, Andhra Pradesh ocuupied a prominent place in Indian livestock sector as the value of livestock output of agriculture was 25.8 and 21.4 per cent at all India and state levels at current prices. With increase in human population, the per capita availability is expected to decrease to 144 gm, in Andhra Pradesh at current levels of milk production. The foundation for the programmes was laid in 1951 with the very first programme, *i.e.* Key Village Scheme (KVS), as a part of the first five year plan, followed by Intensive Cattle Devlopment Project (ICDP), later implemented programmes like Operation Flood Programme (OFP), Goshala Development Programme, and Feed and Fodder Development Programme. So, there is a need to assess status and progress of KVS and ICDP in the development of the livestock sector.

MATERIAL AND METHODS

Data and information pertaining to KVS and ICDP were collected from the secondary sources like Quinquinneal livestock census, and annual administration reports of Directorate of Animal Husbandary. Percentage changes were calculated for the period of 1956-92, to analyse the progress of Key Village Scheme. Percentage method was also used for estmating the Artificial Inseminations (AI) conducted and calf births in Key Village Scheme and Intensive Cattle Development Project from 1982-83 to 1992-93 in Andhra Pradesh. The brief description of KVS and ICDP is follows :

Key Village Scheme (KVS)

The main objectives of the scheme are : introduction of bulls, castration of undesirable

Table 1 : Progress of Key Village Scheme during inter-census period from 1956-1992

Year	1956	1992	% increase
Key village centres	7	12	71.4
Key village comprises villages	2	2	-
Key village block	5	38	660
Sub centres	6	380	6233
A.I. Units	23	1040	4422

inferior bulls, use of artificial inseminations, improved fodder production, prevention and treatment of diseases and distribution of mineral feed supplements.

A very large production of livestock in India does not belong to quality breeds and are of non-descript types. However, in recent times, the value of scientific breeding to increase the powe, efficiency and milk yield of livestock has been organised and in the same lines, seven key village centres were established in Andhra Pradesh.

Key village centres were opened in the breeding tracts, so that, the first generation of animals will be available as pure breed stock for the bull rearing farms. A key village comprises one or more contiguous villages, where they were stationed for collection of semen and its distribution from main station tc the sub-centres for initiation of artificial insemination programme under the supervision of veterinary staff.

Intensive Cattle Devlopment Project :

The objectives of the project in addition to those of KVS are : cattle breeding and establishment of bull rearing farms, castration of scrub bulls, supply of bulls of required quality to areas marked for development, veterinary aid, disease control and provision of veterinary centres, registration of milk recording, subsidies and incentives for milk production, introduction of high yielding milk cattle, feed and fodder development including demonstrations, distribution of fodder seeds, silage making and popularisation of chaff cutters, maximisation of milk production, crossbreeding and establishment of artificial insemination centres and dairy extension.

RESULTS AND DISCUSSION

The progress and percentage success of activities of Key Village Scheme and Integrated Cattle Development Project were calculated and interpreted in Table 1 and 2.

Progress of KVS

Key village centres were expanded to cover a larger area in the breeding tract, a large number of breedable cows and she-buffaloes. In 1971-72, the all India Key Village Scheme envisaged a multi-faceted approach to all aspects of cattle development and marketing, which have a direct bearing on the productivity of the cattle.

The per cent increase in key village centres was 71.4 for the period of 1956-1992, whereas, the number of comprising villages was constant. The increase in key village blocks (660%), sub centres (6233%) and A.I. units (4422%) was very steep.

Constrains of Key Village Scheme

Several constraints were identified in the successful implementation of KVS and those were: the area of operation was confined to limited number of villages with restricted number

Table 2 : Artificial inseminations conducted and calf birth in Key Village Scheme (KVS) and Intensive Cattle Development Project (ICDP) from 1982-83 to 1992-93 in Andhra Pradesh

S.No.	Particulars	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
1	Cows											
	a) A.I.done	3.20	3.40	3.81	4.15	3.08	4.79	5.11	5.69	5.16	5.87	6.34
	b) Calf births	0.61	0.80	0.88	1.02	1.12	1.14	1.41	1.45	1.64	1.63	1.76
	Percentage success	19.06	23.53	23.09	24.58	36.36	23.79	27.59	25.48	31.78	27.77	27.76
2	Buffaloes											
	a) A.I.done	4.55	4.98	5.71	6.25	5.79	7.42	8.15	9.26	9.87	9.77	9.98
	b) Calf births	0.81	1.04	1.21	1.42	1.56	1.52	1.93	2.06	2.36	2.58	2.55
	Percentage success	17.80	20.88	21.19	22.72	26.94	20.49	23.68	22.25	23.91	26.41	25.55
3	Total											
	a) A.I.done	7.75	8.38	9.52	10.40	8.87	12.21	13.26	14.95	15.03	15.64	16.32
	b) Calf births	1.42	1.84	2.09	2.44	2.67	2.66	3.34	3.51	4.00	4.21	4.31
	Percentage success	18.32	21.95	21.95	23.46	30.21	21.79	25.18	23.48	26.61	26.92	26.40

Note : Percentage success of calves born was calculated for all the years (1982-83 to 1992-93)

A.I = Artificial inseminations

of categories, as it was implemented during the first five year plan and low budget allocation towards the execution of the scheme.

The scheme had a good impact on cattle development in those areas, while, the key village programme was in progress and it was realised that for increasing milk production commensurate to the needs, great efforts are needed. In this direction, based on the recommendations of the scientist panel in 1965 for rapid increase on large scale in milk production of cattle in India, Intensive Cattle Development Project was launched.

Progress of ICDP

An intensive Cattle Development Project covered a population of about 1,00,000 breedable cows/buffaloes. This project was linked up with dairy and milk supply schemes. During the third plan period two Intensive Cattle Development Blocks (ICDB) were established around Hyderabad and Vijayawada to augment the milkproduction in milk shed area. These blocks made a significant progress and achieved 30 per cent increase in milk production within a period of five years. There were 12 regional Cattle Development Units with 303 sub-centres in two ICDB covering Krishna, Guntur, West Godavari, Medak, Mehaboobnagar, Nalgonda, Hyderabad and one at Warngal was started in 1971-72.

The propagation of exotic fodder for cattle devlopment activities gained momentum. Under small and marginal farmers devlopment agency schemes, the weaker sections in certain districts were given loans for purchase and maintenance of milch cows.

Realising the success and impact made by implementation of the two ICDBs, the Department of Animal Husbandry had further strengthened these projects and there were 10

ICDP s in 1977-78 and nine major and medium size projects had been started, covering a breedable female bovine population of 13.80 lakhs.

Achievements of ICDP

The significant achievements of ICDP were mentioned as follows:(i) cattle development activities with ICDP in the state had resulted in rapid increase in the number of productive crossbreed cattle like Ongole and improved buffaloes like Murrah, (ii) significant strides were made with the use of frozen semen technology, which ensures optimum use of available semen from the bulls of high genetic merit as well as its preservation for further used and (iii) for scientific and economic management of livestock, nutritious fodder is essential, particularly, in the case of crossbreed animals for increased milk production.

Under KVS and ICDP, artificial inseminations were under progress. The percentage success of claves born to that of inseminations conducted was higher in case of cows than buffaloes. Percentage success of calves born had been on an increased from 1982-83 to 1986-87 in both cows and buffaloes. In 1987-88, 1989-90 and 1992-93, the success trend was declining both for cows and buffaloes. As a whole i.e. 1992-93 over 1982-83 the percentage success had been increased from 19.06 to 27.76 per cent in cows, 17.8 to 25.55 per cent in buffaloes, and 18.32 to 26.40 percentage success on the whole (Table2).

Key Village Scheme that was implemented in 1951 had its growth-impact on decrease in key village centres and increase in artificial inseminations units. A multi-faceted approach to all aspects of cattle development and marketing was established from 1971-72 and as a result of this, the objectives of providing good breeding facilities by intorducing superior bulls were achieved. With the same objectives of KVS, but, with much wider scope, Intensive Cattle Development Project (ICDP) was started during the third five-year plan, which envisaged provision of package of improved practices to the cattle owners to affect a break through in milk production. Artificial inseminations, which were conducted as a part of it, showed a significant increase in the percentage success of calves born to the inseminations done from 1982-83 to 1991-92. For the efficient execution of KVS and ICDP and for better results, non-governmental and farmers organizations should be involved. The existing livestock development activities like artificial insemination and fodder development activities should be strengthened.

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Growth Instability in Production of Redgram in Andhra Pradesh : A District-wise Analysis

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ABSTRACT

An attempt was made to study the patterns of growth in area, production and productivity to examine the magnitude of variability in the production and to identify the districts and regions having combinations of different degree of growth and instability for redgram in Andhra Pradesh. The time series data for the period 1981-82 to 2000-01 were collected from various sources of statistical abstract published by the Bureau of Economics and Statistics, Government of Andhra Pradesh. Compound growth rate was employed to know the growth trends. Coefficient of variation (C.V) and Coppock's Instability Index (C.I.I.) were used to measure the magnitude of instability. Both CGR and CII were utilized for identifying the districts and regions having combinations of different degree of growth and instability. The results revealed that growth performance of redgram production was significant. Besides, recording medium degree of instability in production, instability (growth) in productivity has contributed more towards variability (growth) in production, Major policy implication is, as area under cultivation cannot be increased beyond certain level, the growth in production should come from yield attributing factors like development of high yielding varieties and improvement in input use efficiency.

Key Words : Redgram Production Instability, District-wise Analysis

India ranked first in total pulse production with 27.1 per cent (16 Million Tonnes) of the world production (59 Million Tonnes) during the year 1999. In India, Andhra Pradesh is one of the leading states in cultivation of redgram with the cultivated area of 0.51 million hectares and production of 0.29 million tonnes during 2000-01, with a share of 21 per cent in the total pulses production. India exports redgram and its products to many countries. Shah and Shah (1997) had stated that while, rice and wheat output has grown considerably and there has been a considerable lag in output growth of pulses and coarse cereals. Comparison of various demand estimates with estimated food grain production projections for the year 2000 indicate that India will have a surplus of food grains, but a deficit in pulses. This necessitates to undertake the present study, to estimate the growth rates in area, production and productivity, to ascertain the extent of instability in area, production and productivity and to identify the districts and regions having combinations of different degrees of growth and instability.

MATERIAL AND METHODS

The study pertains to 22 districts, as data for Hyderabad district was not available, and three geographical regions of Andhra Pradesh *viz.*, Coastal Andhra, Rayalaseema and Telangana and State as a whole. Time series data from 1981-82 to 2000-01 were collected from various sources published by Bureau of Economics and Statistics, Government of Andhra Pradesh. For the calculation of compound growth rate (CGR), coefficient of variation (CV) and Coppock's instability index (CII) the whole period was divided into two sub periods resulting in the formation of

Table 1 : Compound growth rates of area, production and productivity of redgram in Andhra Pradesh

Districts Regions and State		Overall Period (1981-82 to 2000-01)			Period-I (1981-82 to 1990-91)			Period-II (1991-92 to 2000-01)		
		Area	Producion	Productivity	Area	Production	Productivity	Area	Production	Productivity
	R	0.8705	1.6166*	0.7397	-1.1278	-1.8336	-0.7139	-0.3771	-0.7010	-0.3253
Srikakulam	S.E	0.049	0.0076	0.0054	0.0185	0.0264	0.0203	0.0025	0.0079	0.0082
	R	2.6915**	3.7743**	1.0548	1.2021	0.6864	-0.5096	2.1457**	2.7842	0.6265
Vizianagaram	S.E	0.0027	0.0061	0.0052	0.0081	0.0189	0.0175	0.0053	0.0129	0.0117
	R	0.9733	0.6635	-0.3068	2.5988**	0.5522	-1.9948	-0.2285	-0.5127	-0.2848
Visakhapatnam	S.E	0.0022	0.0044	0.0044	0.0038	0.0147	0.0140	0.0050	0.0103	0.0103
	R	-3.1841	-1.9022	1.3240	2.1344**	0.7142	-1.3906	-5.7983	-7.3948	-1.6952
East-Godavari	S.E	0.0058	0.0077	0.0073	0.0059	0.0119	0.0142	0.0101	0.0202	0.0224
	R	-2.7502	-1.7495	1.0291	-1.8385	-3.8016	-1.9999	-3.3886	-3.4984	-0.1133
West-Godavari	S.E	0.0034	0.0051	0.0052	0.0106	0.0135	0.0140	0.0092	0.0130	0.0133
	R	1.4599**	2.3056*	0.8335	2.5327**	3.6082*	1.0490	0.7267	2.6921	1.9512
Krishna	S.E	0.0018	0.0044	0.0040	0.0054	0.0140	0.0121	0.0032	0.0116	0.0109
	R	2.2057**	3.6775**	1.4399	-0.6613	-2.9402	-2.2941	4.9923**	3.0402*	-1.8594
Guntur	S.E	0.0041	0.0079	0.0071	0.0093	0.0185	0.0205	0.0058	0.0113	0.0095
	R	2.7807**	4.4802**	1.6535	3.3120**	1.1186	-2.1231	5.2221	6.0371	0.7745
Prakasam	S.E	0.0086	0.0086	0.0106	0.0041	0.0244	0.0222	0.0352	0.0238	0.0362
	R	3.1366**	4.3937**	1.2190	4.1338	2.0614	-1.9901	-0.9998	-0.7460	0.2566
Nellore	S.E	0.0083	0.0170	0.0058	0.0248	0.0353	0.0141	0.0199	0.0212	0.0155
COASTAL	R	1.9582**	3.1065**	1.1262	4.1923*	-0.1761	-4.1927	3.4532*	3.2755	-0.1717
ANDHRA	S.E	0.0047	0.0048	0.0064	0.0133	0.0121	0.0146	0.0105	0.0108	0.0070
	R	0.9844*	3.1982**	2.1922**	4.0769**	3.8159	-0.2509	2.3817**	3.0648	0.6672
Kumool	S.E	0.0043	0.0053	0.0067	0.0108	0.0163	0.0222	0.0067	0.0157	0.0134
	R	0.5413*	3.0082**	2.4535**	2.2674**	1.4056	-0.8427	0.3544	0.2871	-0.0671
Ananthapur	S.E	0.0022	0.0055	0.0057	0.0046	0.0153	0.0141	0.0048	0.0125	0.0107
	R	2.4078**	5.9820**	3.4901**	6.9839**	6.8782**	-0.0988	2.2524	4.0873	1.7943
Kadapa	S.E	0.0063	0.0072	0.0068	0.0147	0.0185	0.0147	0.0150	0.0236	0.0192
	R	0.7342	1.9619**	1.2186	4.2350**	3.7785	-0.4380	-1.9179	1.1931	3.1712
Chitoor	S.E	0.0042	0.0065	0.0059	0.0080	0.0164	0.0146	0.0038	0.0211	0.0186
	R	0.9283**	3.4025**	2.4514**	3.6464**	3.5402*	-0.1024	1.1643	2.1188	0.9435
RAYALA-SEEMA	S.E	0.0032	0.0045	0.0051	0.0064	0.0129	0.0147	0.0060	0.0133	0.0111
	R	1.2543**	2.4847**	1.2152	2.3483**	5.2862*	2.8705	1.6875*	2.9274*	1.2193
Ranga Reddy	S.E	0.0020	0.0054	0.0061	0.0046	0.0221	0.0228	0.0053	0.0118	0.0107
	R	-1.2979	-0.0108	1.3040**	0.0957	0.1384	0.0426	-1.1114	-1.3025	2.4410
Nizamabad	S.E	0.0024	0.0036	0.0041	0.0066	0.0103	0.0139	0.0055	0.0103	0.0089
	R	0.2771	1.1744	0.8949	0.6117	-1.8525	-2.4493	2.5612*	9.3904*	6.6586*
Medak	S.E	0.0034	0.0113	0.0101	0.0063	0.0235	0.0284	0.0093	0.0291	0.0226
	R	0.7360	2.3421**	1.5944*	1.9475**	1.7232	-0.2200	2.4142**	6.9085**	4.3884**
Mahaboobnagar	S.E	0.0037	0.0070	0.0055	0.0050	0.0149	0.0174	0.0126	0.0196	0.0109
	R	1.8166**	2.8335**	0.9987	2.1490**	0.1033	-2.0027	2.4287**	3.4883	1.0344
Nalgonda	S.E	0.0017	0.0058	0.0061	0.0047	0.0154	0.0169	0.0050	0.0165	0.0163
	R	1.9088*	2.9420*	1.0139	-0.2782	-3.2120	-2.9420	8.0000**	4.5203	-3.2220
Warangal	S.E	0.0068	0.0101	0.0090	0.0065	0.0275	0.0275	0.0167	0.0236	0.0121
	R	1.4611**	2.5212**	1.0448**	3.8286**	5.3010**	1.4181	-0.3734	0.6787	1.0560
Khammam	S.E	0.0030	0.0039	0.0024	0.0071	0.0093	0.0085	0.0028	0.0079	0.0057
	R	-1.1055	1.0593	2.1889*	-2.0510	-0.0886	2.0035	3.0585	5.2251	2.1023
Karimnagar	S.E	0.0053	0.0064	0.0038	0.0057	0.0132	0.0130	0.0151	0.0179	0.0094
	R	0.2204	1.5774	1..3540	1.1475	-1.3558	-2.4749	-0.6777	4.8051	5.5202
Adilabad	S.E	0.0019	0.0061	0.0068	0.0049	0.0167	0.0185	0.0043	0.0127	0.0109
	R	0.9084**	2.1651**	1.2652**	1.6527**	2.0153	0.3568	1.7180*	3.9992*	2.2427*
TELANGANA	S.E	0.0021	0.0039	0.0035	0.0041	0.0088	0.0112	0.0065	0.0124	0.0087
	R	1.1635**	2.6609**	1.4999**	2.7756**	1.5524*	-1.1901	2.0606*	3.4372**	1.3488*
	S.E	0.0025	0.0027	0.0034	0.0045	0.0066	0.0094	0.0062	0.0082	0.0040

** 1% Level of significance

* 5% Level of significance

R = Compound growth rate (%)

SE = Standard error of coefficient B

three periods *viz.*, Period-1 (1981-82 to 1990-91), Period-II (1991-92 to 2000-01) and Overall Period (1981-82 to 2000-01) and analysis was conducted separately for each period.

Analytical Tools

I. Estimation of growth rates

Compound growth rates of area, production and productivity of red gram for the all districts, three regions and the state as a whole for periods mentioned earlier by fitting an exponential function of the following form.

$$Y = Ab^t$$

$$\text{Log } Y = \text{Log } A + t . \log b$$

where,

Y= Area production productivity A= Constant

b= (1+r) r= Compound growth rate

t= Time variable in years (1,2,3...n)

II. Estimation of extent of Instability

Calculation of extent of instability CV and CII were employed.

1) Coefficient of variation (CV)

Which explains the fluctuations over the period.

$$CV = \frac{[1/_{N-1}\ \Sigma(X_t-\overline{X})^2]^{1/2}}{\overline{X}}$$

where,

N = Number of years

X_t = Area/production/productivity in the year 't'

X = Mean of area/production/productivity.

2) Coppock's instability index (CII)

Coppock's instability index (CII) is a close approximation of the average year-to-year percentage variation adjusted for trend.

In algebraic form:

$$C.I.I. = [\text{Antilog} \sqrt{\log V} - 1] . 100$$

(Kaul and Singal, 1988)

$$\log V = \frac{[\log (X_{t+1}/X_t) - m]^2}{N-1}$$

where

X_t = Area/production /productivity in the year 't"

log V= Logarithmic variance of the series.

m= Arithmetic mean of the difference between the logs of X_{t+1} etc.,

N= Number of years

III. Growth versus Instability

Growth rates and Instability Indices in isolation will explain respectively the growth performance and variability pertinent variable of crop over a period of time. But, by taking in conjugation of both then only can be identified whether the crop's performance is stabilized higher growth rate or instabilised lower growth rate. Accordingly, red gram production in district(s) or region(s) was classified into four categories (as shown in Table). So, this enables the development of district or region specific strategies rather than old blanket strategy of state as a whole. For rating the district(s) or region(s) as high or low growth rates and instability, crop growth rate (CGR) and Coppock's instability index (CII) state as a whole were taken as critical point. Further, analysis was carried out for the overall period and discussion was proceeded according to the categories with highly preferable to not preferable.

RESULTS AND DISCUSSION

I Growth rates

Discussion was proceeded level-wise. At each level all the three periods were discussed.

Table 2 : Coefficient of variation (CV) and Coppock's instability indices (CII) of area production and productivity of redgram among the districts, regions and state as a whole in Andhra Pradesh during the period 1981-82 to 2000-2001 (values in percentages)

Districts Regions and State	Overall Period						Period-1						Period-II					
	Area		Production		Productivity		Area		Production		Productivity		Area		Production		Productivity	
	C.V	C.I.I	C.V	C.I.I	C.V	C.I.I	C.V	C.I.I	C.V	C.I.I	C.V	C.I.I	C.V	C.I.I	C.V	C.I.I	C.V	C.I.I
Srikakulam	22.93	14.33	35.81	23.62	30.78	15.29	29.91	17.28	39.88	24.90	42.28	18.64	5.52	2.28	17.46	4.79	16.46	5.70
Vizainagaram	38.39	18.03	55.02	27.91	30.69	13.80	18.23	8.03	33.92	15.22	33.61	14.32	17.37	5.81	25.95	7.94	23.19	8.52
Visakhapatnam	17.06	7.22	24.39	12.31	24.61	11.10	19.07	7.55	27.42	13.53	30.14	13.23	9.43	4.23	19.44	8.50	18.62	8.89
East Godavari	46.42	27.10	52.11	25.09	57.98	22.08	18.60	6.59	23.94	10.37	28.55	13.60	49.02	17.70	75.66	29.48	54.28	21.90
West Godavari	42.17	18.06	45.31	14.23	31.88	15.42	26.64	7.83	47.21	10.84	30.18	13.24	28.85	12.04	37.39	12.17	23.50	9.22
Krishna	20.17	8.62	38.56	18.37	26.11	11.73	19.13	7.49	31.32	17.04	22.73	11.30	7.88	3.52	31.33	13.49	27.62	11.45
Guntur	42.08	17.72	59.40	32.71	41.07	21.45	134.84	8.52	46.70	19.90	62.02	20.73	34.57	13.24	27.30	12.87	21.27	9.58
Prakasam	63.58	29.96	108.01	38.09	113.53	32.52	24.30	9.02	46.48	22.46	41.59	22.22	56.98	40.12	87.29	26.74	112.0	34.20
Nellore	56.79	30.81	73.49	44.90	42.15	17.64	44.31	27.38	63.57	36.08	30.24	13.26	39.65	18.90	43.85	19.55	37.91	13.74
COASTAL ANDHRA	45.26	16.98	55.84	28.17	31.98	18.92	57.48	17.47	23.57	10.47	35.02	19.60	33.59	14.04	38.10	13.41	14.52	6.13
Kurnool	29.66	12.00	52.92	24.02	40.92	23.18	36.31	14.67	46.89	18.27	38.97	21.00	23.53	9.50	37.64	17.54	23.09	11.97
Ananthapur	14.51	6.25	47.36	22.98	43.32	21.14	18.40	7.84	31.01	13.21	27.30	12.39	10.05	4.33	22.64	11.28	19.81	9.54
Kadapa	46.31	22.86	86.73	45.01	60.51	29.21	54.76	26.66	62.78	28.11	27.63	13.19	37.48	15.21	54.96	25.01	35.00	18.18
Chittoor	21.80	10.34	41.88	19.83	37.62	17.71	27.89	13.10	37.36	16.58	28.16	13.19	14.80	6.14	36.29	17.76	37.83	15.54
RAYALASEEMA	21.79	9.38	51.46	23.40	41.24	20.43	27.60	11.87	37.18	14.60	27.69	13.21	15.67	6.44	31.38	13.13	20.73	10.29
Ranagareddy	20.54	8.76	47.92	22.13	42.79	17.37	19.27	7.95	63.27	25.66	60.17	22.60	16.04	6.96	32.62	13.67	22.71	9.96
Nizamabad	22.32	9.77	20.23	9.46	28.50	13.58	15.34	5.52	26.19	9.15	32.68	12.64	12.91	5.26	20.16	10.04	20.73	11.03
Medak	21.29	8.95	74.67	33.73	54.66	29.18	14.39	5.80	47.53	22.78	51.16	28.32	28.02	11.69	86.74	44.58	62.57	31.62
Mahaboobnagar	25.04	10.74	71.50	24.82	43.97	18.22	15.20	7.30	35.94	14.70	43.06	15.71	30.50	13.26	73.93	30.05	40.96	17.02
Nalgonda	26.85	11.46	51.26	24.66	36.55	17.57	16.09	7.28	29.60	13.12	36.78	14.87	19.05	8.63	35.82	18.72	31.03	14.17
Warangal	64.31	22.51	77.46	35.57	48.07	26.06	13.19	4.57	53.02	25.05	54.91	26.57	69.50	30.70	63.95	26.99	35.78	11.08
Khammam	23.79	10.98	36.14	17.66	19.21	8.69	29.92	12.73	39.92	17.72	17.76	8.58	6.24	2.29	15.25	7.16	12.96	5.99
Karimnagar	31.41	15.07	47.11	18.11	33.97	17.25	20.50	7.00	30.39	9.30	26.35	13.10	38.64	17.00	55.99	24.21	20.99	10.76
Adilabad	11.71	4.95	47.53	19.05	48.74	20.54	10.90	5.55	39.53	15.66	45.87	19.04	9.92	3.31	45.43	19.41	46.22	19.70
TELANGANA	18.14	7.59	42.06	17.01	26.95	12.01	14.46	6.14	22.62	9.91	25.34	10.10	18.19	7.84	38.17	17.29	21.69	10.51
ANDHRA PRADESH	22.78	9.25	44.18	17.64	26.69	12.80	23.28	9.07	16.89	6.91	20.24	9.24	20.30	8.49	32.24	13.12	12.11	5.36

Table 3 : Districts and regions of Andhra Pradesh with combinations of different magnitudes of growth rates and instability indices in redgram

	High growth rate and low instability		High growth rate and high instability		Low growth rate and low instability		Low growth rate and high instability	
	District(s)	Regions(s)	District(s)	Regions(s)	District(s)	Regions(s)	District(s)	Regions(s)
	Guntur	------------	Vizianagaram Prakasam	COASTAL ANDHRA	Visakhapatnam	TELANGANA	Srikakulam	------------
				RAYALASEEMA	West Godavari		East Godavari	
	Nellore				Nizamabad		Krishna	
	Kunnool						Chittoor	
					Khammam			
	Ananthapur						RangaReddy	
	Kadapa						Medak	
	Nalgonda						Mahaboobnagar	
	Warangal						Karimnagar	
							Adilabad	
% Of average production to the State average production	11.71	--------	37.17	50.47	14.00	49.53	37.12	----------

Note : 1. CGR for redgram production for state as a whole during the period 1981-82 to 2000-01 is 2.6809%.

2. CII for redgram production for state as a whole during the period 1981-82 to 2000-01 is 17.64%.

3. Total average redgram production for the period 1981-82 to 2000-01 is 94996 Tonnes.

Among all the districts, during the overall period, for area, production and productivity significant growth rates were observed in thirteen, sixteen and seven districts respectively (Table 1). During the period I, significant growth rates in area, production and productivity were noticed in twelve, four and none districts, respectively. During the period II, significant growth rates in area, production and productivity were noticed in seven, seven and four districts, respectively. With regard to the lowest and the highest growth rates were observed during the overall period in area and they were - 3.1841 per cent (East Godavari) and 3.1366 per cent (Nellore), in production they were - 1.9022 per cent (East Godavari) and 5.9820 per cent (Kadapa) and in productivity they were -0.3068 per cent (Visakhapatnam) and 3.4901 per cent (Kadapa). That shows East Godavari with the lowest area and production growth rates and Kadapa with the highest production and productivity growth rates were recorded. During the period I, growth rates in area varied from -2.0510 per cent (Karimnagar) to 6.9839 (Kadapa), in production varied from -3.8016 per cent (West Godavari) to 6.8782 per cent (Kadapa) and in productivity it varied from -2.9420 per cent (Warangal) to 2.8705 per cent (Ranga Reddy). So, Kadapa showed the highest growth rates in area and production during the period I. During the period II growth rates in area, production and productivity of the lowest were recorded as -5.7983 per cent (East Godavari), -7.3948 per cent (East Godavari) and -3.2220 per cent (Warangal) respectively, whereas, of the highest were recorded as 8.00 per cent (Warangal), 9.3904 per cent (Medak) and 6.6586 per cent (Medak), respectively.

Among the regions, Coastal Andhra had shown significant growth rates in area (1.9582%) and production (3.1065%) in overall period and area in the period I (4.1923) and the period II

(3.4532%). In case of Rayalaseema area and production in period I and all the three variables in the overall period has shown significant growth rates. Similarly, in Telangana, except production and productivity in period I, in all the periods all the variables had shown significant growth rates.

For state as a whole, except productivity in period II, all variables in all the periods have shown significant growth rates. Growth rates in area, production and productivity were 1.1635 per cent, 2.6809 per cent and 1.4999 per cent respectively during the overall period, during the period I they were 2.7756 per cent, 1.5524 per cent and -1.1901 per cent respectively and during the period II they were 2.0606 per cent, 3.4372 per cent and 1.3488 per cent, respectively.

Above results revealed that there was a significant positive and trend in redgram during the study period. Inter period comparison between two sub-periods revealed that growth rates for production and productivity were higher in period II than period I. Further, growth in production was more contributed by productivity than area.

The reasons for positive trend in production and productivity were, red gram has more remunerative than other pulses, role in diet and red gram was somewhat hard crop, so it can withstand natural vagaries. Irrigation facilities for red gram was good many districts and last but not least because of availability of some high yielding varieties. But, still there is ample scope for increase the growth rates in area, production and productivity if there is congruence between farmers need, agricultural research and nature's grace.

II Extent of Instability

Growth rates will explain only rate of growth over the period, whereas, instability will judge, whether the growth performance is stable or unstable for the period for the pertinent variable. While, furnishing the results both (C, V and C.I.I.) were placed adjacently to get better picture. Results and discussion proceeded period wise and in each period all levels were discussed thoroughly.

During the overall period, in the State as a whole, instability in area, production and productivity respectively were recorded as 22.78 per cent CV and 9.25 per cent CII, 44.18 per cent CV and 17.64 per cent CII and 26.69 per cent CV and 12.80 per cent CII (Table 2). Thus, there was high instability in all the three variables, of which, in production it was very high. Further, instability in productivity in relation to instability in area has contributed marginally more towards production fluctuations. Among the regions, the lowest instability in area (18.14%CV and 7.59%CII), production (42.06%CV and 17.01%CII) and productivity (26.95%CVand 12.01%CII) were recorded in Telangana. The highest variability in area (45.26%CV and 16.98%CII) and production (55.84% CV and 28.17% CII) were in Coastal Andhra and in productivity was (41.24%CV and 20.43%CII) in Rayalseema. Instability in area in Coastal Andhra and instability in productivity Rayalaseema and Telangana has contributed more towards fluctuations in production. Further, on average, instability in production was high in all the regions, than other two variables. Among the districts, the lowest instability in area, production and productivity were recorded respectively in Adilabad (11.71%CV and 4.95%CII), Nizamabad (20.23% CV and 9.46%CII) and Khammam (19.21% CV and 8.69%CII). The highest instability in area, production and productivity, in terms of CV and CII, were observed in Warangal (64.31%) and Prakasam (29.96%), Prakasam (108.01 and Cuddapah (45.01%) and in Prakasam (113.53%) and Khammam (8.69%) respectively. Thus the lowest in all the variables was recorded in among the districts of Telangana region. Moreover, 15 out of 22 districts instability. in productivity has contributed more towards production fluctuations.

During the period I, State as a whole, instability in area (23.28% CV and 9.07 CII) has contributed marginally more in relation to instability in productivity (20.24% CV and 9.24% CII) towards fluctuation in production (16.89% CV and 6.91% CII) as indicated in Table 2. Among the regions, the lowest instability in area, production and productivity were recorded in Coastal Andhra and instability in productivity, marginally, in Rayalaseema, and substantially, in Telangana has contributed more towards instability in production. Among the districts, 19 out of 22 districts had shown higher yield instability and like wise they contributed towards production fluctuations.

During the period II, State as a whole, instability in area (20.30% CV and 8.49% CII) in relation to instability in productivity (12.11% CV and 5.36% CII) has contributed more towards instability in production (32.24% CV and 13.12% CII). Among the regions, the lowest instability in area and production were observed in Rayalaseema, but Coastal Andhra has recorded with the lowest instability in productivity. The highest instability in area was noticed in Coastal Andhra, whereas, in production and productivity were observed in Telangana. Thus, instability in area in coastal and instability in productivity, in Rayalaseema and Telangana has more effect on production fluctuations. Among the districts, 15 out of 22 districts had shown higher yield instability than the area instability and like wise they contributed towards production fluctuations. Further, Prakasam has shown high instability in all three variables.

III. Growth versus instability

i) High Growth Rate and Low Instability (highly preferable): Only Guntur district was in this category (Table 3). This implies production in Guntur with stabilized higher growth rate. Though only one district but, has 11.7 per cent of average state production, signifies the importance of crop in that district. The further increase in production can be achieved with break through in technology, because production function parameters differ significantly from old to new technology, (Raju and Rao, 1988).

ii) High growth rate and high instability (Preferableness is based on the graterness of growth rate over instability index): Coastal Andhra and Rayalaseema regions and eight districts were placed in this category. Separately, total of the two regions and total of eight districts shares 50.47 per cent and 37.17 per cent respectively to the states average production. Further, out of four districts of Rayalaseema three districts were placed in this category. In this category even though growth rate is high but stability is low. This necessitates giving primary concern to production stabilization. Because; higher production with uncertainity will not be of much use to the farmers. Production fluctuations in redgram production was more contributed by the yield variability than the area variability (Table 2). So, this imperates the timely supply of required amount of inputs. Further, any break through in production performance of higher magnitude should come through varietal effect.

iii) Low growth rate and low instability (less preferable) : Among the districts four districts and among the regions, Telangana were constituted in this category. But, Telangana region share of 49.53 per cent of total state average production. So, in region wise identification this category should be given prime importance. Stagnant production is of much concern in this category. Stagnation in production should be overcome through yield attributing factors, as growth in production was more contributed by growth in productivity in Telangana region (Table 1). Yield attributing factors like HYV's, increasing input-use efficiency and etc., should be given more importance.

iv) Low growth rate and high instability (Not preferable): The districts having the share of 37.12 per cent in state average production were constituted in this category. This means 1/3 of Red gram production was in dismal situation of low growth rate and high variability condition. This requires strategies to increase the growth and decrease the instability. Production can be enhanced through higher input-use efficiency and development of farming system specific crop varieties. Providing the assured supply of inputs in time and quantity can reduce instability.

To surmise, for State as a whole, during the overall period, growth rate in productivity (1.4999%) was marginally higher than the growth rate in area (1.1635%) and like wise contributed towards growth in production (2.680%) (Table 1). Productivity (26.69% CV and 12.80% CII) has higher instability than are (22.78% CV and 9.25% CII) and likewise contribution towards the production fluctuations (44.18% CV and 17.64% CII) (Table 2). These imply growth in production was significant and highly instable. Further, productivity has marginally higher effect on production than the area. The suggestions are :

1) As area under cultivation cannot be increased beyond certain level, the growth in production should come from yield attributing factors like development of High Yielding farming system specific varieties and improvement in input use efficiency.
2) Growth in production was of something reckonable but had not reached its potential. This necessitates through yield gap analysis.
3) Production was more contributed by productivity in redgram this indicates there is a need of in depth study about productivity attributing factors.
4) Identified high and low growth rates and instability districts and regions for redgram will be better utilized in the local specific and crop specific research schemes and growth oriented development programmes.

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Comparative Economics of Seed and Non-seed Production of Jowar in Kurnool District of Andhra Pradesh

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ABSTRACT

The hybrid seed production is specialized operation that calls for a higher level of competence to meet quality requirements as compared to non-seed crop. This research was conducted in Gospadu and Dornipadu mandals of Kurnool district in Andhra Pradesh. The operational and fixed costs per hectare on an average for seed farm were Rs.16,837.14 and RS. 10,193.61 and for non-seed irrigated farms Rs. 12,082.69 and Rs. 9,617.62 and for non-seed rainfed farms Rs. 5,500.56 and Rs. 4,390.66, respectively. The net returns for seed, non-seed irrigated and non-seed rainfed farms were Rs. 15,556.75, Rs. 7,869.54 and Rs. 4,101.53, respectively for the sample as a whole. The results indicated that the cost of cultivation as well as net returns were more on seed farms compared to non-seed farms.

Key Words : Comparative Economics, Seed Production, Jowar

In India nearly 80 per cent seed production of hybrid sorghum is concentrated in Andhra Pradesh. This research problem studies the comparative economics of seed and non-seed production of jowar with the specific objective to work out costs and returns in seed and non-seed production of jowar in different farm sizes and identify the production and marketing constraints in jowar seed production.

MATERIAL AND METHODS

In Kurnool district, Gospadu and Dornipadu mandals were purposively selected. Forty farmers for seed production and 40 for non-seed production (20 inrrigated and 20 rainfed farmers) were randomly selected from the selected villages. Thus the sample consists of 80 farmers for the present study.

The cost of cultivation including variable costs like human labour, cattle labour, machine power, seed cost with registration fee, material inputs, irrigation charges and interest on working capital etc. and fixed costs *viz.*, land revenue, rental value of owned land, depreciation charges and interest on fixed capital etc. were worked out in order to estimate the cost of production, net income and benefit/cost ratio for seed, non-seed irrigated and non-seed rainfed jowar farms.

RESULTS AND DISCUSSION

The total operational costs per hectare were more on seed farms compared to non-seed farms. In the operational costs, human labour, seed cost and material inputs absorbed more than 44 per cent of total cost of cultivation on jowar seed farms. In the variable costs human labour occupied 17.38 per cent followed by seed cost with registration fee (10.24 per cent) fertilizers (9.01 per cent) cattle labour (8.37 per cent) and machine power (6.71 per cent) on pooled farms. In the non-seed crop, the operational and fixed costs both are more in irrigated condition than rainfed situation. In the variable costs, human labour was the highest 15.30 per cent followed by fertilizers (9.86 per cent), cattle labour (9.26 per cent) and machine

Table 1 : Cost of cultivation of jowar seed and non-seed farms (size wise and component wise) (in rupees per hectare)

S. No. Particulars	Seed farms			Non-seed irrigated farms			Non-seed rainfed farms		
	Small farms	Large farms	Average farms	Small farms	Large farms	Average farms	Small farms	Large farms	Average farms
1. Operational costs									
1. Human labour	4,951.50 (18.00)	4,951.50 (16.77)	4,708.50 (17.38)	3,442.50 (15.70)	3,201.50 (14.90)	3,322.00 (15.30)	1,745.50 (17.34)	1,559.00 (16.04)	1,652.25 (16.69)
a. Owned human labour	1,216.08 (4.42)	727.37 (2.73)	971.97 (3.58)	1,163.56 (5.31)	752.35 (3.50)	957.95 (4.41)	689.47 (6.85)	436.52 (4.49)	562.09 (5.67)
b. Hired human labour	3,735.41 (13.58)	3,737.32 (14.04)	3,736.51 (13.80)	2,278.93 (10.39)	2,449.15 (11.40)	2,364.04 (10.89)	1,056.03 (10.49)	1,122.48 (11.55)	1,089.25 (11.02)
2. Cattle lobour	2,922.00 (10.63)	1,630.00 (6.02)	2,276.00 (8.37)	2,470.50 (11.27)	1,560.00 (7.26)	2,015.25 (9.26)	1,431.50 (14.22)	1,321.50 (13.60)	1,316.50 (13.91)
a. Owned cattle labour	1,154.19 (4.18)	1,134.48 (4.26)	1,144.33 (4.22)	953.61 (4.35)	1,063.92 (4.95)	1,008.76 (4.65)	543.97 (5.40)	938.26 (9.65)	741.11 (7.52)
b. Hired cattle labour	1,767.81 (6.45)	495.52 (1.86)	1,131.66 (4.15)	1,516.89 (6.92)	496.08 (2.31)	1,006.48 (4.61)	887.53 (8.82)	383.23 (3.94)	653.38 (6.38)
3. Machine power	1,258.50 (4.58)	2,358.00 (8.85)	1,808.25 (6.71)	1,465.50 (6.69)	2,257.50 (10.51)	1,861.50 (8.60)	741.20 (7.36)	829.50 (8.54)	785.35 (7.95)
a. Owned machine power	-	2,358.00 (8.85)	1,179.00 (4.42)	-	970.72 (4.52)	485.36 (2.26)	-	270.41 (2.78)	135.20 (1.39)
b. Hired machine power	1,258.50 (4.58)	-	629.25 (2.29)	1,465.50 (6.69)	1,286.78 (5.99)	1,376.14 (6.34)	741.20 (7.36)	559.09 (5.75)	616.29 (6.22)
4. Seed cost with Registration fee	2,898.00 (10.54)	2,647.60 (9.94)	2,772.80 (10.24)	430.40 (1.96)	310.02 (1.44)	370.21 (1.70)	167.72 (1.67)	138.65 (1.43)	153.18 (1.55)
5. Manures	869.00 (3.16)	2,503.50 (3.03)	838.20 (3.09)	760.50 (3.47)	733.80 (3.42)	747.15 (3.45)	447.60 (4.45)	398.70 (4.10)	429.12 (4.28)
6. Fertilizers	2,376.00 (8.64)	807.40 (9.40)	2,439.75 (9.01)	2,100.00 (9.58)	2,178.00 (10.14)	2,165.00 (9.86)	575.00 (5.71)	598.50 (6.16)	595.50 (5.94)
7. Plant production chemicals	1,252.50 (4.56)	2,503.50 (4.88)	1,275.50 (4.72)	996.00 (4.54)	1,047.00 (4.88)	1,021.50 (4.71)	351.00 (3.49)	362.40 (3.73)	366.70 (3.61)
8. Irrigation charges	248.70 (0.90)	1,298.50 (0.89)	242.85 (0.89)	247.60 (1.13)	232.84 (1.08)	240.22 (1.12)	-	-	-
9. Interest on working capital	524.25 (1.90)	498.34 (1.87)	511.29 (1.88)	372.27 (1.70)	360.00 (1.68)	366.13 (1.68)	170.61 (1.70)	162.75 (1.67)	166.68 (1.68)
Total operational costs	17,300.45 (62.91)	16,445.84 (61.75)	16,837.14 (62.29)	12,285.27 (56.04)	11,880.11 (55.31)	12,082.69 (55.68)	5,630.13 (55.94)	5,371.00 (55.27)	5,500.56 (55.61)
II Fixed costs									
1. Land revenue	200.00 (0.73)	200.00 (0.75)	200.00 (0.74)	200.00 (0.91)	200.00 (0.93)	200.00 (0.92)	12.50 (0.12)	12.50 (0.13)	12.50 (0.12)
2. Rental value of owned land	9,000.00 (32.72)	9,000.00 (33.79)	9,000.00 (33.30)	8,500.00 (38.78)	8,500.00 (39.58)	8,500.00 (39.17)	3,750.00 (37.26)	3,750.00 (38.59)	3,750.00 (37.92)
3. Depreciation charges	508.00 (1.85)	468.60 (1.76)	488.30 (1.81)	481.00 (2.19)	424.00 (1.98)	452.50 (2.09)	346.40 (3.44)	217.50 (2.24)	281.95 (2.84)
4. Interest on fixed capital	491.55 (1.79)	519.07 (1.95)	505.31 (1.86)	456.94 (2.08)	473.31 (2.20)	465.12 (2.14)	326.03 (3.24)	366.39 (3.77)	346.21 (3.51)
Total fixed cos.ts	10,199.55 (37.09)	10,817.67 (38.25)	10,193.61 (37.71)	9,637.94 (43.96)	9,597.31 (44.69)	9,617.62 (44.32)	4,434.93 (44.06)	4,346.39 (44.73)	4,390.66 (44.39)
Total costs	27,500.00 (100.00)	26,633.54 (100.00)	27,030.75 (100.00)	21,923.21 (100.00)	21,477.42 (100.00)	21,700.31 (100.00)	10,065.06 (100.00)	9,717.39 (100.00)	9,891.22 (100.00)

Note : Figures in parentheses indicate percentages to the total costs.

Table 2 : Cost concepts in jowar seed and non-seed production (in rupees per hectare)

S. No.	Particulars	Seed farms			Non-seed irrigated farms			Non-seed rainfed farms		
		Small farms	Large farms	Average farms	Small farms	Large farms	Average farms	Small farms	Large farms	Average farms
1.	Cost A_1/A_2	16,792.37 (61.06)	16,386.57 (61.52)	16,553.47 (61.15)	11,802.71 (53.83)	11,751.76 (54.71)	11,777.23 (54.27)	5,299.56 (52.65)	5,164.48 (53.14)	5,232.02 (52.89)
2.	Cost B	26,283.92 (95.57)	25,905.64 (97.26)	26,058.78 (96.27)	20,759.65 (94.69)	20,725.07 (96.49)	20,742.36 (95.58)	9,375.59 (93.14)	9,280.87 (95.50)	9,328.23 (94.30)
3.	Cost C	27,500.00 (100.00)	26,633.51 (100.00)	27,030.75 (100.00)	21,923.21 (100.00)	21,477.42 (100.00)	21,700.31 (100.00)	10,065.06 (100.00)	9,717.39 (100.00)	9,891.22 (100.00)

Note : Figures in parentheses indicate percentages to Cost C.

power (8.60 per cent) for irrigated non-seed crop. For the rainfed crop, human labour occupied 16.69 per cent followed by cattle labour (13.91 per cent) machine power (97.95 per cent) and fertilizers (5.94 per cent) of the total per cent of cost of cultivation. In the fixed costs, rental value of owned land occupied the large proportion for all the categories of farms. The cost of production of seed and non-seed jowar exhibited negative relationship with the farm size indicating the operation of economies of scale production.

The results of cost concepts indicated that cost A (Rs. 16,553.47), cost B (Rs. 26,058.72) and cost C (Rs. 27,030.75) in jowar seed production were more compared to non-seed irrigated farms (Rs. 11,777.23, Rs. 20,742.36 and Rs. 21,700.31) and non-seed rainfed farms (Rs.5,232.02, Rs.9,328.23 and Rs.9,891.22) for the sample as a whole. It was found that cost concepts showed inverse relationship with the size of the farm in both jowar seed and non-seed production.

On an average the selected farmers produced 40.48 quintals of grain on jowar seed farms, 43.91 quintals on non-seed irrigated farms and 19.81 quintals on non-seed rainfed farms. Out of the total yield on seed farms, the female seed yield and male seed yield was 27.18 quintals and 13.30 quintals. At the time of processing 31.42 per cent of female seed was rejected for not meeting the standards prescribed. There was no marked difference between small and large farms in the productivity on seed and non-seed farms.

The sample farmers incurred Rs. 667.76, Rs.494.23 and Rs.499.42 to produce a quintal of jowar on seed farms, non-seed irrigated and rainfed farms, respectively. An inverse relationship was observed between cost of production and size of the farm.

The gross returns per hectare of jowar seed production, non-seed production under irrigated and in rainfed situation on pooled farms were Rs. 42,587.50, Rs. 29,569.85 and Rs.13,992.75 respectively. The net returns from seed production were Rs. 15,556.75 for the sample as a whole compared to Rs. 7,869.54 and Rs. 4,101.53 per hectare on non-seed irrigated and rainfed farms respectively.

The farm business analysis of jowar seed and non-seed production revealed that all the measures of farm income *viz.*, net income, farm business income, family labour income and farm investment income were positively related with the size of the farm in the case of seed farms as well as non-seed farms. The benefit-cost ratio was 0.58, 0.37 and 0.42 for seed production, non-

Table 3 : Output and returns per hectare of jowar seed and non-seed production

S. No.	Particulars	Units	Seed farms			Non-seed irrigated farms			Non-seed rainfed farms		
			Small farms	Large farms	Average farms	Small farms	Large farms	Average farms	Small farms	Large farms	Average farms
1.	Yield in physical units										
	a. Main product	quintals	40.29	40.67	40.48	43.76	44.06	43.91	19.64	19.98	19.81
	i. Female seed	quintals	18.56	18.72	18.64						
	ii.Male seed	quintals	13.21	13.39	13.30						
	iii. Reminent seed	quintals	8.52	8.56	8.54						
	b. By-product	tonnes	7.38	7.45	7.42	6.70	6.83	6.77	4.30	4.47	4.39
2.	Yield in monetary units										
	a. Main product	Rs.	38,705.00	39,055.00	38,880.00	25,818.40	26,656.30	26,237.35	11,587.60	12,087.90	11,837.75
	b. By-product	Rs.	3,690.00	3,725.00	3,707.50	3,350.00	3,415.00	3,332.50	2,150.00	2,235.00	2,155.00
3.	Gross returns	Rs.	42,395.00	42,780.00	42,587.50	29,168.40	30,071.30	29,569.85	13.737.60	14,322.90	13,992.75
4.	Cost of cultivation	Rs.	27,500.00	26,533.51	27,030.75	21,923.21	21,477.42	21,700.31	10,065.06	9,717.39	9,891.22
5.	Net returns	Rs.	14,895.00	16,146.49	15,556,75	7,245.19	8,593.88	7,869.54	3,672.54	4,605.51	4,101.53

seed production under irrigated and rainfed conditions respectively. Seed production yielded the highest net returns per rupee of expenditure. Large farmers registered higher benefit-cost ratio compared to small farmers both on seed and non-seed farms.

The major problems in production and marketing of seed jowar as revealed by the opinion survey were inadequate labour supply, insufficient credit facilities, incidence of pests and diseases, adulteration of inputs like pesticides and seeds, high prices of inputs such as foundation seed, fertilizers and pesticides, lack of technical know-how, lack of remunerative price for jowar seed, risk of rejection of considerable quantity of produce at the time of processing etc.

Seed production is more profitable than non-seed crop. The cost of cultivation of seed farms was more compared to non-seed farms. In all the farms human labour followed by fertilizers occupied the higher per cent of total cost of cultivation. In the seed production, seed cost was higher in total cost of cultivation after the human labour. In the fixed costs, rental value of owned land occupied major portion in the total cost of cultivation for all the farms.

There was not much difference in productivity between size groups in seed and non-seed production of jowar. The unit cost of production was more in jowar seed production (Rs. 668.72 per quintal) compared to non-seed production (Rs. 494.23 per quintal under irrigation and Rs. 499.42 per quintal under rainfed conditions).

Net returns exhibited direct relationship with the farm size on seed as well as non-seed farms of jowar. The net returns from seed production (Rs. 15,556.75 was almost double compared to non-seed production under irrigation (Rs. 7869.54) and three times more than the net returns from non-seed production in rainfed situation (Rs. 4,101.53). The benefit-cost ratio showed positive relationship with the size of holding. The net returns per rupee of expenditure were higher in jowar seed production compared to non-seed production.

There is an immediate need to provide adequate institutional finance to jowar seed production as it entailed higher expenditure

Table 4 : Costs and returns per quintal of jowar seed and non-seed (in rupees per quintal)

S. No.	Particulars	Seed farms			Non-seed irrigated farms			Non-seed rainfed farms		
		Small farms	Large farms	Average farms	Small farms	Large farms	Average farms	Small farms	Large farms	Average farms
1.	Costs									
	a. Variable costs	429.40	404.37	415.94	280.74	269.63	275.17	286.67	268.82	277.66
	b. Fixed costs	253.15	250.50	251.82	220.25	217.82	219.03	225.81	217.54	221.64
	c. Total costs	682.55	654.87	667.76	500.99	487.45	494.20	512.48	486.36	499.30
2.	Returns									
	a. Gross returns	960.66	960.29	960.47	590.00	605.00	597.50	590.00	605.00	597.50
	b. Net returns	278.11	305.42	292.71	89.01	117.55	103.30	77.52	118.64	98.20

Table 5 : Measures of farm income in jowar seed and non-seed production (in rupees per hectare)

S. No.	Particulars	Seed farms			Non-seed irrigated farms			Non-seed rainfed farms		
		Small farms	Large farms	Average farms	Small farms	Large farms	Average farms	Small farms	Large farms	Average farms
1.	Gross income	42,395.00	42,780.00	42,587.50	29,168.40	30,071.30	29,569.85	13,737.60	14,332.90	13,992.75
2.	Net income	14,895.00	16,164.49	15,556.75	7,245.19	8,593.88	7,869.54	3,672.54	4,605.51	4,101.53
3.	Farm business income	25,602.63	26,393.43	26,034.03	17,365.69	18,319.54	17,792.62	8,438.04	9,158.42	8,760.73
4.	Family labour income	16,111.08	16,874.36	16,528.72	8,408.75	9,346.23	8,827.49	4,362.01	5,042.03	4,664.52
5.	Farm investment income	24,386.55	25,683.56	25,026.06	16,202.13	17,567.19	16,834.67	7,748.57	8,721.9	8,197.74
6.	Benefit cost ratio	0.54	0.61	0.58	0.33	0.40	0.37	0.36	0.47	0.42

compared to non-seed / commercial production of jowar. Secondly the government should adopt suitable price support policies so as to ensure a remunerative price to seed growers.

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Financing of Agriculture in Karnataka State-A Case Study of Uttara Kannada District

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ABSTRACT

Agriculture is the backbone of the Indian economy and at the same time it is the most backward sector. Agriculture contributes around 25 per cent to national income and employs around 75 per cent of total population. Agriculture provides food for our population, raw material for industries, market for industrial products and opportunities for export earnings.

Key words : Agricultural Financing

Indian agriculture has came a long way from subsistence farming to commercial farming and presently undergoing rapid transformation under the spell of globalisation. Significant achievements have been made in food, milk, oilseeds and fish production through green, white, yellow and blue revolutions respectively. However, its contribution to the GDP declined from 88.6 per cent in 1980 to 24.9 per cent in 2000 (Business Line, 2004). This indicates the need for increasing the production and productivity through the use of high yielding varieties and diversification of land use.

The income of majority of Indian farmers is low and unable to meet the financial needs of agriculture with their own savings. Hence, they need adequate finance from financial institutions to meet their agriculture requirements.

Uttara Kannada district is the 10th largest district located in the North of Karnataka State. The district is endowed with the most cultivating landscape, silver white beaches, cool palm groves, picturesque river valleys and rich hilly forest. Around 80 per cent of total land in the district is covered with forest and the rest of land is available for cultivation. Further, more than 75 per cent of total population is inhabited in the rural areas and majority of them depend on agriculture for their livelihood. Progress of the district depends on the progress of the agriculture. However, the farmers in the district are suffering from shortage of financial resources due to their low savings. As the Indian farmers born in debt, lives in debt and bequeaths in debt equally apply to the farmers of the district (Satyasundaram, 2002). Hence, provision of sufficient finance is essential to the farmers of the district at the time when they need.

MATERIAL AND METHODS

The study covers the different aspects of financing related to agriculture such as bank-wise targets and achievements, outstanding advances and recovery of credit in the district for the last five years. The study is purely based on the secondary data collected from district annual credit plan from the lead district bank, with the following objectives.

To analyse effectiveness in achieving targets in agriculture credit, To analyse the bank

Table 1 : Bankwise targets and achivements in agriculture credit (Rs.in crore)

	Banks											
	CB			RRB			KDCCB			TOTAL		
Year	T	A	%	T	A	%	T	A	%	T	A	%
99-00	12.89	13.60	105.51	4.40	6.12	139.09	29.19	34.03	116.58	46.48	53.75	115.64
00-01	15.08	16.23	107.63	5.49	5.27	95.99	29.16	32.36	110.97	49.73	53.86	108.30
01-02	17.04	17.61	103.35	6.61	6.20	93.79	45.18	45.25	100.15	68.63	69.06	100.63
02-03	27.91	20.48	73.38	12.02	10.04	83.53	44.84	55.02	122.70	84.77	85.54	100.91
03-04	24.09	24.75	102.74	9.65	9.50	98.45	59.65	58.41	97.92	93.39	92.66	99.22

Source : District Annual Credit Plan of the related year. T-Target, A-Achievements

wise outstanding agriculture credit, to examine the effectiveness in recovery of agriculture credit and to offer useful suggestions to improve the financing of agriculture.

RESULTS AND DISCUSSION

Provision of sufficient amount of credit to the farmers is necessary to improve the agriculture income by adopting high yielding varieties and modern technology. Right amount of credit at right time to farmers depends on the systematic credit planning and its implementation by the banks in the district. Comparing the actual achievements with targets assess the effectiveness of agriculture credit planning. The bank-wise targets and achievements in agriculture credit are depicted in the Table 1.

It is revealed from the Table 1 that achievements in agriculture credit exceed the targets in the district during the study period except during 2003-04. This indicates the efficiency in credit planning at lead district bank by lead manager and its implementation by the concerned banks. Further, it reveals that RRB lagging behind CB and KDCCB in the district during the study period. RRB in the district fails to fulfil its obligation of meeting the targets in financing to agriculture except during 1999-00.

Agriculture is the part of priority sector and obligatory to all CB, RRB, and CO-OP to lend minimum 18 per cent of total advances to agriculture in the concerned financial year. Effectiveness of banks in the district in lending to agriculture can be assessed through analysis of outstanding agriculture advances to total advances. Bankwise outstanding agriculture and total advances in the district are shown in the Table 2.

It is clear from the Table 2 that the total outstanding agriculture credit from the banks in the district crossed the benchmark of 18 per cent of total outstanding advances in the study period. This signifies the interest of banks in advancing to agriculture in the district during the study period. Further, bankwise analysis reveals that CB and RRB crossed the benchmark of 18 per cent of total advances to agriculture whereas, KDCCB meets the standard only during 2003-04. This indicates that KDCCB has concentrated more on financing to other sector in the study period.

Financial soundness of banks depends on the timely recovery of credit. Recovery of right amount at right time leads to rise in the financial performance of banks. Timely recovery of credit saves lot of expense and solves the problem of non-performing assets. However, presently

Table 2 : Bank wise outstanding agriculture and total advances and percentage of total advances to agriculture (Rs.in crore)

	Banks											
	CB			RRB			KDCCB			TOTAL		
Year	Agr	Total	%	Agr	Total	%	Agr	Total	%	Agr	Total	%
99-00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
00-01	94.30	373.50	25.25	11.70	57.30	20.42	35.90	197.90	18.14	141.90	628.70	22.57
01-02	87.80	389.20	22.56	12.80	61.40	20.85	30.40	208.60	14.57	131.00	659.20	19.87
02-03	116.70	442.80	26.36	15.70	73.40	21.39	34.30	226.50	15.14	166.70	742.70	22.45
03-04	128.00	535.30	23.91	18.80	85.60	21.96	97.40	225.10	43.27	244.50	846.00	28.90

Source : District Annual Credit Plan of the related year. Agr-Target, NA-Not available

Table 3 : Recovery position of agriculture credit in the disttrict (Rs.in crore)

Year	Demand	Collection	Balance	Recovery %
1999-00	56.24	46.24	10.00	82.22
2000-01	62.09	50.02	12.07	80.56
2001-02	46.64	33.17	13.47	71.12
2002-03	38.02	30.38	7.64	79.91
2003-04	41.42	31.74	9.68	76.61

Source : District Annual Credit Plan of the related year

banks are suffering from low recovery of credit and increased amount of non-performing assets. The recovery position of banks in agriculture advance in the district is presented in the Table 3.

It is clear from the Table 3 that the recovery in agriculture credit was above 70 per cent and varies in between 71.12 per cent to 82.22 per cent during the study period. This signifies the efforts of banks in recovery of agriculture credit. The recovery percentage stepped down till the end of 2001-02 and went up in 2002-03, but again decreased in 2003-04 as compared to their respective previous year. This indicates lack of consistency in the recovery of credit during the study period.

On the basis of analysis and findings of the study, the following suggestions are offered to make the financing of agriculture more effective.

1) Increasing the targets: Use of high yielding varieties fertilizers and modern technology are very essential to increase the production and productivity in the agriculture sector.

2) Arranging awareness programmes: Many farmers in the district are less literate and they have less knowledge about the assistance from institutional source of finance. Educating the farmers through various awareness programmes is very essential to bring out the farmers from the clutches of rural lenders.

3) Timely sanction of credit: Timely sanction of credit not only helps the farmers to avoid borrowing at higher rate but also solves the problems of banks in recovery of credit.

4) Pre-sanction and post -sanction follow-up: Bank financing has favourable impact on farmers only when they utilise the finance for the proper end use. Hence, bank officers must make Pre-sanction and post-sanction follow-up for the benefit of farmers and banks.

5) Reducing the rate of interest: Government should not announce any policy that affects adversely the banking sector. The policy of principle and interest waiver may have good impact on farming community but on the side acts an incentive to borrow without repaying ethics. The government can try to reduce the rate of interest on agricultural loan instead of announcing the policy of loan waiver.

6) Easy and convenient system: Financing procedure to agriculture should be simple in order to attract all the farming community.

7) Control on non-institutional source of finance: Bring strict regulation on non-institutional source of finance to avoid charging of high interest rate and irrational recovery of credit.

8) Improving the recovery of credit: Timely recovery of credit is essential for the sound financial health of banks and farming community. Hence, the need to improve the recovery mechanism is very essential in the district.

Bank finance assumes greater significance in the growth of agriculture in the district in particular and in India in general. Ensuring timely supply and sufficient amount of credit has beneficial impact on the farmers and banks. Hence, banks in the district should apply appropriate techniques of lending and recovery of credit in order to improve their financial health.

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A Study on Costs and Returns in Cultivation of Cassava in East Godavari District of Andhra Pradesh

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ABSTRACT

This study on different size groups of farm, to study the cost and return of cassava production, revealed that with regards to cost of production of per hectare among all the size groups, the total costs were high on large farms with Rs. 16,169.52 followed by medium Rs. 15,165.00 and small farms Rs. 13,127.41. Thus a direct relationship was observed between total cost of cultivation and farm size. The maximum share of the cost of production was constituted by human labour irrespective of the farm size.

Key words : Costs and Returns, Cassava Cultivation, East Godavari

Among root and tuber crops, cassava is an important starchy root crop of the tropics. It has the potential to produce highest dry matter production per day. A major caloric contributor it is well adopted to the drought conditions.

In India cassava is cultivated in 0.24 million ha producing 6 million tonnes. The area and production followed the global trends in the early nineties but stagnation has set in Kerala, where the crop was first introduced in India, accounted for 50 per cent of the area under cassava (0.13 million ha) Tamil Nadu accounts for 32 per cent of the area (0.08 million ha) and 9 per cent of area in Andhra Pradesh (20,000 ha). It is interesting to note that through India does not have major area under this crop, its productivity is the highest in the world (24.50 tonnes/ha). In Andhra Pradesh, East Godavari district has a lion share in production (93 per cent) and area followed by the agency areas of Srikakulam, Vizianagaram and Visakhapatnam districts as rainfed crop, while the productivity of cassava in Andhra Pradesh stagnated at 10 tonnes/ha.

MATERIAL AND METHODS

East Godavari was purposively selected for the study since selected for the study it is the only district in Andhra Pradesh cassava to an extent of 18,550.40 ha in 2003-04. All the mandals of the district were arranged in descending order of their areas separately under kharif during 2003-04 and the top three mandals were selected.

The cassava cultivators of the six villages were listed and arranged in the ascending order of their total operational holdings. They were stratified into three size groups *viz.*, small (below 2 ha), medium (2 to 4 ha) and large (above 4 ha). In proportion to the number of cultivators available in each of these three size groups 45 small, 23 medium and 22 large farmers were selected at random making the total size of the sample '90' for the present study. The data pertaining to the selected cassava farms were obtained through survey method and enquiries were made with the help of pre-tested schedules. The data were statistically analysed.

Table 1 : Costs and returns on cassava farms according to farm size (Rs/ha)

Particulars	Small		Medium		Large	
	Cost	Per cent	Cost	Per cent	Cost	Per cent
A. Operational Costs :						
Manures	700.52	5.34	712.00	4.69	720.60	4.46
Fertilizers	2026.66	15.43	2486.18	16.39	2558.71	15.82
Seed	1801.04	13.72	1828.66	12.06	1842.54	11.40
Human labour	4775.00	36.37	4890.00	32.25	4980.00	30.80
Machine labour	1150.00	8.76	1192.00	7.86	1260.00	7.79
Bullock labour	632.91	4.82	716.85	4.73	723.70	4.48
Interest on working capital	461.92	3.52	492.73	3.25	503.56	3.11
Interest on fixed capital	458.04	3.49	928.17	6.12	1005.84	6.22
Total operational costs	**12006.09**	**91.45**	**13246.59**	**87.35**	**13594.95**	**84.08**
B. Fixed Costs :						
Depreciation	449.53	3.43	874.17	5.76	1076.76	6.66
C. Family labour wages	671.79	5.12	1044.30	6.89	1497.81	9.26
Total Costs (A+B+C)	**13127.41**	**100.00**	**15165.06**	**100.00**	**16169.52**	**100.00**

Table 2 : Cost of cultivation of cassava according to cost concepts

Particular	Small	Medium	Large
Cost A	12,006.09	13,246.59	13,594.95
Cost B	12,455.62	14,120.76	14,671.71
Cost C	13,127.41	15,165.06	16,169.52

RESULTS AND DISCUSSION

It can be observed that the cost of cultivation per hectare was Rs. 13,127.41 on small farms, Rs. 15,165.06 on medium farms and Rs. 16,169.52 on large farms (Table 1). The breakup of total cost of cultivation indicated that was a positive relationship between variable costs and total costs of cultivation and costs varied from 12,006.09 on small farms to Rs.13,594.95 on large forms. However, the per cent share of the variable costs showed in inverse relation with farm size which accounted for 91.45 per cent to total costs on small farms, 87.35 per cent on medium farms, 84.08 per cent on large farms. Thus variable costs accounted to 84 to 91 per cent of total expenditure on cassava farms in the study area.

The first major component human labour was the highest of all variable costs which accounted for Rs.4,775, Rs.4,890 and Rs.4,980 on small, medium and large farms, respectively. The share of human labour expenditure in total expenditure was 35 per cent on small, 32 per cent on medium and 30 per cent on large farms. This shows that cassava is a labour intensive crop.

The next major component was fertilizers which accounted for Rs.2,026 on small farms, Rs.2,486.18 on medium farms and Rs.2,558.71 on large farms, which also indicted a direct relationship with the farm size. The next one was cost of seed which accounted for Rs.1,842.54 on large farms.

Table 3 : Unit cost of production

Particulars	Output/ha (qt / ha)	Total cost of cultivation (Rs / ha)	Cost of Production (Rs / qt)
Small	190	13,127.41	69.09
Medium	208	15,165.06	72.90
Large	220	16,169.52	73.49

Table 4 : Income from the cultivation of cassava farms according to farm income measures (Rs/ha)

Sl.No.	Particulars	Small	Medium	Large
1	Gross Income	27,930.00	30,576.00	32,340.00
2	Net Income	14,802.59	15,410.94	16,170.48
3	Farm business Income	15,923.91	17,329.41	18,745.05
4	Family labour Income	15,474.38	16,455.24	17,668.29
5	Farm investment Income	15,252.12	16,285.11	17,247.24
6	Cost benefit ratio	1 : 2.12	1 : 2.01	1 : 2.0

Cost of cultivation of cassava according to cost concept

The total cost of cultivation was further presented in Table 2 based on the cost concepts such as cost A_1, Cost A_2 , Cost B, Cost C which are widely used in farm management studies. In the study area there was no leasing activity among the selected farmers so cost A_1 and A_2 remained to be the same.

Unit cost of production

Unit cost of production calculated in (Table 3) yield per unit of land indicate the productivity of a particular crop. It varied from 190 quintal per hectare on small farms to 220 quintal per hectare on large farms. The same for medium farms was 208 quintal per hectare. The per quintal cost of production on large, medium and small farms was Rs. 73.49, Rs. 72.90 and Rs. 69.09, respectively.

Farm income measures

It was measured in terms of net income, family labour income, farm business income and farm investment income. The various measures of farm income were calculated (Table 4). Net income was maximum in large farm size groups followed by medium and small farms. The per cent share of net income to gross income was 53 on small farms, 50 on medium farms and 50 on large farms, respectively.

On an average family labour income of Rs. 15,474.38, Rs. 16,455.24 and Rs. 17668.29 was realized on small, medium and large farms, respectively. Farm business income was Rs. 15,923.91, Rs. 17,329.41 and Rs. 18,745.05 on small, medium and large farms, respectively. Thus there was a clear positive relationship between farm business income and the farm size.

Gross and net returns

The gross and net returns of different farm sizes are presented in (Table 5). It can be observed that the gross returns included the value of the physical output in monetary terms. The gross returns per hectare for cassava worked

Table 5 : Gross and net returns

Particulars	Gross Returns	Total Cost	Net Returns
Small	27,930.00	13,127.41	14,802.59
Medium	30,576.00	15,165.06	15,410.94
Large	32,340.00	16,169.52	16,170.48

out to Rs. 27,930.00 on small farms, Rs. 30,576.00 on medium and Rs. 32,340.00 on large farms respectively.

The result indicated a positive relationship between the total cost of cultivation and farm size group. The highest yield in large farms were due to the fact that when farms have adopted better cultural practices when compared to small and medium farms. The cassava crop was labour as well as capital intensive. The net returns can further be increased by reducing the unnecessary additional expenditure on various inputs without effecting the physical output.

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Demand Projections for Cotton in Andhra Pradesh : 2019-20

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ABSTRACT

The consumption of cotton by mills were mainly influenced by price of cotton crop, competing crop price (chillies), production and trend variable with statistically significant co-efficients (0.266, -0.113, 0.174 and 0.116). The projected values of the consumption of cotton by mills would be 739.12 '000 bales in 2005-06, 898.06 '000 bales in 2015-16 and 966.96 '000 bales by the year 2019-20. The total demand for cotton (including the cotton consumption for Khadhi production, weaving, knitting *etc.*,) will be 953.21 '000 bales in 2005-06, 1066.08 '000 bales in 2015-16 and 1119.48 '000 bales by the year 2019-20.

Key words : Demand Projections, Cotton

In the present day context cotton is crucially important crop as a source of income and employment and as a source of foreign exchange earner. It is the major source of "clothing" apart from other fibre sources like *viz.,* jute, silk and synthetic. In India, Andhra Pradesh occupies third position in terms of area and production and second place in terms of productivity. As the population is increasing at an alarming rate, the increasing demand for cotton has functional relationship with population growth. Therefore, this study in an attempt in this direction to project the demand for cotton in Andhra Pradesh by the year 2020.

MATERIAL AND METHODS

The present study is limited to the twenty year period of 1984-85 to 2003-04 and based on secondary data. Information needed for the study was collected from Statistical Abstract of Andhra Pradesh, CCI reports and Textiles of Compodium Publications. The following functional relationship has been identified for analyzing the pattern of cotton consumption.

$$C_t = f(P_t, P_t^c, M_t, Q_t, T_t)$$

where,

C_t = Consumption of cotton by mills in the year t
P_t = Price of the cotton crop in year t
P_t^c = Price of the competing crop in year t
M_t = Number of mills in year t
Q_t = Production of cotton crop in year t
T_t = Trend variable

Based on the demand functions, two multiple regression equations one with log specification and another without log specification have been estimated as given below.

$$\text{Log } C = \alpha + b_1 \log P_t + b_2 \log P_t^c + b_3 \log M_t + b_4 \log Q_t + b_5 \log T_t + E$$

$$C = \alpha + b_1 P_t + b_2 P_t^c + b_3 M_t + b_4 Q_t + b_5 T_t$$

where α and E are constant and the error term respectively,

b_1, b_2, b_3, b_4 and b_5 are the co-efficients of the respective variables.

Table 1 : Regression equation of demand for cotton consumption by mills with log specification

Variable	Regression co-efficient	Standard error	Significance	R^2
P_t	0.266	0.115	Sig**	
P_t^c	-0.113	0.063	Sig*	
M_t	-0.004	0.063	Non Sig	0.948
Q_t	0.174	0.115	Sig*	
T_t	0.116	0.055	Sig**	

Constant = 45.517 * Significant at 5% level ** Significant at 1% level

The suitability of either of these functions is generally determined on the basis of goodness of fit as specified by the value of R^2 and significance of the coefficients.

RESULTS AND DISCUSSION

The demand projections are made based on the demand function or equation for Andhra Pradesh. The demand function was analyzed with two specifications one is with log specification and the other is without log specification. As the values of the demand function without log specification are unrealistic, the log specification demand equation is used in the present study for the demand projections.

The results obtained from log specification demand equation for the cotton crop is presented in Table 1. The co-efficient of multiple determination (R^2) was 0.948 indicates that nearly 94 per cent of the total variation in the cotton consumption by mills was explained by the independent variables. Thus the fitted demand function was given by

$$Y = 45.51\, P_t^{0.266}\, P_c^{t-0.113}\, M_t^{-0.004}\, Q_t^{0.174}\, T_t^{0.116}$$

The regression coefficient of price of cotton crop (0.266) and trend variable (0.116) are statistically significant. Akin to that the coefficients of competing crop price (-0.113) and production (0.174) are statistically significant. The number of mills in Andhra Pradesh has not shown any significant relationship with the consumption of cotton by mills.

It was observed from Table 1 that the coefficient of the price of cotton crop (0.266) or demand price elasticity showed positive significant relation with the consumption of cotton by mills. Positive demand price elasticity would induce demand for high quality cotton in years to come.

Generally millers prefer good quality of cotton though the price is high, hence the demand consumption might have been increased with the increase in price.

The coefficient of competing crop price (-0.113) has shown a negative significant relation with the consumption of cotton by mills. As the price of competing crop (chillies) decreases the price of cotton crop increases ultimately there would be a shift from chillies to cotton crop there by increasing the production of cotton hence we could meet the domestic demand for cotton.

It was evident that the coefficient of production (0.174) in the current year has shown

Table 2 : Projected values of total consumption of cotton in Andhra Pradesh '000 bales

Year	Consumption by mills	Consumption by others	Total domestic consumption of cotton
2005-06	739.12	214.09	953.21
2006-07	754.32	208.89	963.21
2007-08	769.65	203.90	973.55
2008-09	785.11	199.02	984.13
2009-10	800.73	194.27	995.00
2010-11	816.50	189.62	1006.12
2011-12	832.45	185.09	1017.54
2012-13	848.57	180.67	1029.24
2013-14	864.87	176.35	1041.22
2014-15	888.37	172.14	1053.51
2015-16	898.06	168.02	1066.08
2016-17	914.96	164.01	1078.97
2017-18	932.07	160.09	1092.16
2018-19	949.40	156.26	1105.66
2019-20	966.96	152.52	1119.48

1 bale = 170 kg

a significant positive influence on the consumption of cotton by mills. This might be due to the fact that as the production of cotton crop increases, the price of the cotton crop decreases further the consumption of cotton by mills increases only if the desired and good quality of cotton is made available.

Table 2 shows the projected values of the consumption of cotton by mills. The consumption by mills would be 739.12 '000 bales in 2005-06, 816.50 '000 bales in 2010-11, 898.06 '000 bales in 2015-16 and 966.96 '000 bales by the year 2019-20. The consumption by mills is increasing at an annual (compound) growth rate of 1.934 per cent in long run (2005-06 to 2019-20) and 2.021 per cent in short run (2005-06 to 2019-20).

The consumption of cotton by mills (domestic consumption) is increasing but the percentage change over previous year is decreasing. This might be due to the decrease in the quality of the cotton, which is due to the vagaries of monsoon, spurious seed, pest attack etc.

Based on the compound growth rates the consumption of cotton by others like khadi production, weaving mills etc. were projected. By adding the consumption by mills and consumption by others we could get the total domestic consumption (domestic demand) of cotton. Table 2 shows that the total demand for cotton would be 953.21 '000 bales in 2005-06, 1006.12 '000 bales in 2010-11, 1066.08 '000 bales in 2015-16 and finally 1119.48 '000 bales by the year 2019-20.

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Research Note

Yield and Nutrient Uptake of *Rabi* Sunflower as Influenced by Moisture Regimes and Nutrient Management

Key Words : Sunflower, Nutrient Management, Moisture Regimes

Sunflower is widely accepted by the Indian farmers because of its role in combating the atherosclerosis and related disorders as the oil is rich in polyunsaturated fatty acids (PUFA). In increasing the productivity of any crop, in general and sunflower in particular, water and nutrient management play a vital role. Therefore, the present investigation was carried out to know the effect of moisture and nutrients on the seed, stalk yield and nutrient uptake of *rabi* sunflower.

Field experiment on irrigation water and nutrient management for *rabi* sunflower was carried out for two years during 1995-96 and 1996-97 at Tirupati campus of Acharya N.G. Ranga Agricultural University. Four moisture regimes based on IW/CPE ratio of 0.60 (I_1), 0.80 (I_2), 1.0 (I_3) and 1.2 (I_4) allotted to main plots and four levels of nutrients of $N_{40} + P_2O_{5\ 20} + K_2O_{\ 20}$ (M_1), $N_{60} + P_2O_{5\ 40} + K_2O_{\ 40}$ (M_2), $N_{80} + P_2O_{5\ 60} + K_2O_{\ 60}$ (M_3) and $N_{100} + P_2O_{5\ 80} + K_2O_{\ 80}$ kg ha^{-1} (M_4) allotted to sub-plots were tested on *rabi* sunflower (KBSH-I) in split - plot design with three replications.

Soil of the experimental field was clay loam in texture, neutral to slightly alkaline in reaction, low in organic carbon, medium in available phosphorus and potassium. Field capacity (FC) of the soil ranged from 10.72 to 13.50 per cent, permanent wilting point (PWP) ranged from 3.11 to 3.20 per cent and bulk density 1.40 - 1.51 g cc^{-3}. The test variety, KBSH-1 selected for study was sown with inter- and intra-row spacing of 45 cm x 20 cm.

Plant samples collected (at different stages of crop growth) and at harvest were sun dried, later oven dried till it attained a constant weight and made in to fine powder using grind mill and is used for the analysis of nitrogen by micro kjeldahl method (Jackson, 1967), phosphorus by Vanadomolybdic phosphoric yellow colour method (Jackson, 1973) and potassium content by ELICO Flame photometer using triacid digest and nutrient uptake was calculated by multiplying the nutrient content by drymatter and expressed in kg ha^{-1}.

Moisture regimes, nutrient levels and their interaction influenced significantly seed, stalk yield and nutrient uptake at harvest, during both the years of study (Table 1 and 2).

Pooled analysis indicated significantly higher seed yield when irrigations were scheduled at closer intervals I_4 (20.15 q ha^{-1}) followed by I_3 (19.46 q ha^{-1}). Increased head diameter, number of filled seeds per head, filling and threshing percentage and test weight were recorded with higher moisture regimes (I_4 and I_3) which was mainly responsible for higher seed yield. Similar results were reported by Sarmah *et al.*, (1994) and Bhowmick *et al.*, (1994). Application of higher level of nutrients resulted in significantly more seed yield.

Table 1 : Seed and stalk yield (q ha^{-1}) of *rabi* sunflower as influenced by moisture regimes and nutrient management (Pooled mean of 1995-96 and 1996-97)

Moisture Regimes	Nutrient management									
	Seed Yield					Stalk Yield				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
I_1	10.02	11.81	17.89	18.76	14.62	21.75	23.42	27.03	28.76	25.24
I_2	11.00	14.05	21.03	21.46	16.89	22.69	25.37	31.93	32.47	28.11
I_3	12.37	17.91	23.74	23.81	19.46	24.12	27.82	34.25	35.14	30.33
I_4	12.63	18.41	24.55	25.01	20.15	24.27	28.06	34.84	35.35	30.63
Mean	11.51	15.55	21.80	22.26		23.21	26.17	32.01	32.93	

Seed Yield (C.D. at P=0.05) : I = 0.77; M = 0.64; M at I = 1.28; I at M = 1.25

Stalk Yield (C.D. at P=0.05) : I = 1.14; M = 0.93; M at I = 1.86; I at M = 1.83

Table 2 : NPK uptake (kg ha^{-1}) of *rabi* sunflower at different stages as influenced by moisture regimes and nutrient management during 1995-96 and 1996-97

Moisture Regimes	Nutrient management									
	1995-96					1996-97				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
	N uptake at harvest					N uptake at harvest				
I_1	30.75	37.80	48.50	49.00	41.50	29.25	35.25	48.25	48.75	40.37
I_2	31.20	43.50	54.40	54.50	45.90	31.00	39.40	52.30	52.50	43.80
I_3	33.50	48.50	85.90	88.00	63.97	32.20	47.80	86.50	86.50	62.70
I_4	34.00	48.25	86.00	88.20	64.11	33.15	47.80	86.60	86.60	63.01
Mean	32.36	44.51	68.70	69.92		31.40	42.56	68.58	68.58	
	P uptake at harvest					P uptake at harvest e				
I_1	6.28	8.88	13.48	14.21	10.71	6.60	9.28	14.21	14.47	11.14
I_2	6.38	11.09	19.53	19.66	14.16	6.76	10.71	20.21	20.47	14.54
I_3	7.13	15.75	30.34	30.16	20.85	7.42	14.89	29.98	30.12	20.60
I_4	7.16	15.85	30.34	30.39	20.84	7.49	15.05	29.99	30.19	20.68
Mean	6.74	12.89	23.24	23.61		7.06	12.48	23.59	23.81	
	K uptake at harvest					K uptake at harvest e				
I_1	12.16	17.35	26.58	26.80	20.72	12.11	17.17	26.39	26.89	20.64
I_2	12.34	27.19	38.39	38.67	27.64	12.40	20.13	38.12	38.61	27.32
I_3	14.03	37.98	77.81	77.92	51.93	13.92	34.96	76.89	77.23	50.75
I_4	14.17	38.24	77.81	78.93	52.28	14.04	35.39	76.92	77.44	50.94
Mean	13.17	28.69	55.15	55.58		13.11	26.91	54.58	55.04	

	C.D. (P=0.05)			C.D. (P=0.05)		
	N uptake	P uptake	K uptake	N uptake	P uptake	K uptake
I =	1.69	0.37	0.69	3.86	0.26	0.56
M =	1.29	0.32	0.75	3.73	0.20	0.56
M at I =	2.57	0.65	1.51	7.47	0.41	1.12
I at M =	2.94	0.66	1.30	7.02	0.45	1.04

Pooled data indicated that $N_{100} + P_2O_{5\ 80} + K_2O_{\ 80}$ kg ha^{-1} (M_4) recorded higher seed yield (22.26 q ha^{-1}) followed by $N_{80} + P_2O_{5\ 60} + K_2O_{\ 60}$ kg ha^{-1} (M_3) (21.80 q ha^{-1}) which were at par and significantly superior to other two levels. Similar results were also reported by Hiremath *et al.*, (1990).

Pooled mean indicated (Table 1 and 2) significant interaction effects in increasing seed yield. Maximum seed yield was obtained with I_4M_4 (25.01 q ha^{-1}) followed by I_4M_3 (24.55 q ha^{-1}). Similar trend was noticed in the case of stalk yield.

Nutrient uptake was significantly more when irrigations were scheduled at IW/CPE of 1.20 followed by 1.00 at all the stages of crop growth. Increased seed yield influenced the nutrient uptake significantly. Maximum N uptake was recorded in I_4, closely followed by I_3 which did not differ significantly at different stages of growth during both the years of study (Table 1 and 2). The lowest N uptake was recorded in I_1 moisture regime which differed significantly with I_2. The highest N uptake was recorded with highest level of nutrient supply (M_4) which was comparable with M_3 and significantly superior to other nutrient levels M_2 and M_1. Similar results were reported by Kharwara and Bindra (1992) and Susheel Kumar *et al.*, (1995). Interaction indicated that the highest N uptake was recorded with I_4 M_4 closely followed by I_3 M_4, I_4 M_3 and I_3 M_3. Similar trend was recorded in P and K uptake.

In conclusion, combination of irrigation scheduling at closer intervals (IW/CPE ratio of 1.20 or 1.00) and higher level of nutrient management (N, P_2O_5 and K_2O at 100-80-80 or 80-60-60 kg ha^{-1}) has resulted in the highest NPK uptake, seed and stalk yield of *rabi* sunflower.

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Research Note

Performance of Ricebean (*Vigna umbellata*) Varieties in The High Altitude Area of Visakhapatnam District in Andhra Pradesh

Key Words : Ricebean, Traditional Pulse, Agency Areas, Andhra Pradesh

Ricebean (*Vigna umbellata*) is a climbing annual herb, locally known as Timmerlu or Katingulu in the agency areas of Visakhapatnam district. In India it is found in both wild as well as cultivated form from lower altitude to temperate Himalayas including North East hills upto an elevation of 2000 m above sea level. It has also been found in Central China through Malaysia. It is believed to have originated in South and East Asia. It is sown as *kharif* crop being sown during May-June and harvested during November and December.

Ricebean is nutritively at par with other pulse crops such as mung bean, urdbean and cowpea but it has an added advantage over others as it is less vulnerable to diseases and insect pests (Negi *et al.*, 1995). It can with stand adverse climatic/edaphic conditions and more over involves less expenses in growing. Seed has also good storage capability. Germinated fried ripe seeds may prove as good source of fast food in near future.

Ricebean is the second largest pulse crop grown by the tribals of high altitude and tribal zone of Visakhapatnam fits well into these systems. However, the yields of this crop were very low (2 - 3 Q/ha). There is a huge potential gap to be exploited without disturbing the traditional farming system by replacement of the traditional varieties with high yielding cultivars suitable to this zone. Therefore, present study was conducted to identify the ricebean varities suitable to the high altitude and tribal area of Visakhapatnam district.

A varietal evaluation study was conducted with 12 varieties of ricebean for two consecutive seasons *i.e., kharif* 2000 (June-November) and *kharif* 2001 (June-November) as a part of ICAR Adhoc Project "Network Project on Tribal Area Crops of MP, AP and Orissa" at Regional Agricultural Research Station, Chintapalle, Andhra Pradesh situated at an altitude of 900 m above MSL. The study included the varieties obtained from Orissa, Madhya Pradesh, Punjab and Andhra Pradesh *viz.*, BRS-2, Chaukhamba, MNPL-1, MNPL-2, MNPL-3, Naine, PRR-1, PRR-2, RBL-1, RBL-6, Semiliguda local and CPRB-1. Experiment was conducted in sandy loam soil under rainfed upland conditions and in simple randomized block design the plots size was 3 m x 4 m size with three replications with inter-and intra-row spacing of 45 x 15 cm, respectively.

A fertilizer dose of 40:40:20 (N, P_2O_5 and K_2O kg/ha) was applied 20 kg N/ha. Nitrogen was applied in two splits *i.e.,* 20 kg N/ha as basal and the remaining at 30 DAS. Observations were recorded on randomly chosen 10 competitive plants in each plot in each replication for number

Table : Growth and yield characters of different ricebean varieties in High Altitude Tribal zone of Visakhapatnam

Variety	Days to 50% flowering			Days to Maturity			Plant height at maturity (cm)			No.of pods/plant			No.of seeds/pod			100 seed weight			Grain yield (q/ha)		
	2000	2001	Pooled	2000	2001	Pooled	2000	2001	Pooled	2000	2001	Pooled	2000	2001	Pooled	2000	2001	Pooled	2000	2001	Pooled
BRS-2	55	56	56	117	120	119	274	213	250	37	16	26.5	6	6	6	6.2	8	7.1	8.74	0.3	4.62
Chaukhamba	61	62	62	124	123	124	148	124	136	35	22	28.5	8	8	8	7	7.1	7.03	7.48	1.91	4.69
MNPL-1	115	116	116	162	160	161	349	304	327	40	21	30.5	4	4	4	24.6	24.9	24.8	18.78	7.1	12.93
MNPL-2	115	115	115	165	162	164	338	296	317	41	27	34.3	6	7	6.5	17.2	16.5	16.9	24.74	17.82	21.28
MNPL-3	115	116	115	162	161	162	293	256	275	59	25	42.3	10	10	10	6	5.5	5.8	24.81	11.84	18.33
Naine	55	56	56	116	116	116	217	171	195	34	16	25.2	9	9	8.8	7	7.1	7.1	13.33	0.38	6.86
PRR-1	55	55	55	115	116	116	137	111	124	21	6	13.5	8	8	8	6.1	6.3	6.2	5.74	0.38	3.06
PRR-2	55	57	56	114	114	115	160	122	141	27	12	19.7	10	9	9.5	7	7.1	7.1	11.15	0.85	6.0
RBL-1	57	59	58	117	126	119	253	209	231	38	26	24.7	9	9	9	7	7.2	7.1	14.52	1.91	8.22
RBL-6	57	56	57	117	120	119	248	201	225	38	19	32.2	8	8	8.	6.9	7.5	7.2	17.00	6.00	11.54
Semiliguda	98	97	98	151	160	156	250	177	213	33	14	26.2	9	10	9.5	6.9	7.5	7.2	12.29	4.03	8.16
CPRB-1	132	131	132	181	180	181	385	302	344	22	11	16.7	10	9	9.5	9	9.1	9.0	11.5	8.3	9.93
S.Em±	0.97	0.86	0.75	0.74	2.01	1.09	8.97	18.62	10.61	3.22	1.84	1.92	0.83	0.61	0.47	0.1	0.16	0.11	1.1	0.22	0.47
CD	2.85	2.5	2.0	2.0	6.0	3.0	26.32	54.14	31.12	9.44	5.37	5.61	2.46	1.76	1.38	0.32	0.48	0.32	3.25	0.65	1.39
CV	2.08	1.78	2.0	0.94	2.47	1.37	6.1	14.93	7.94	15.61	19.12	12.43	17.98	13.27	10.11	2.03	3.05	2.03	13.54	8.63	8.52

of pods per plant, number of seeds per pod, grain yield and test weight. Average rainfall during the crop growth period was 753.9 mm in the year 2000 and 725.9 mm during the year 2001 against a decennial average of 972.3 mm indicating a deficit of 28% during the first year and 34% during the second year of study.

Growth and flowering

The Ricebean variability provides great potential for exploiting various useful economic traits. Considerable variability was observed in days to 50% flowering (Table 1) and days to maturity as also reported by Negi, *et al.*, 1995 and Arora *et al.*, 1980. CPRB-1 recorded more days to 50% flowering (136) and days to maturity (181). PRR-1 recorded less days to 50% flowering (55 days) at par with BRS-2, Naine, PRR-2 and RBL-6. Maximum plant height was recorded by CPRB-1 (343.5 cm), may be due to the pronounced indeterminate growth habit of the variety. PRR-1 recorded less plant height (124cm) at par with Chaukhamaba and PRR-2.

Yield components and grain Yield

More number of pods were observed in MNPL-3 (42.3) and less number were observed in PRR-1 (13.5) on par with CPRB-1. More number of seeds were observed in MNPL-3 on par with PRR-2, Naine, RBL-1, Semiliguda local and CPRB-1. Less no. of seeds were observed in MNPL-1.

Maximum test weight was observe in MNPL-1 (24.8g) and minimum was observed in MNPL-3 (5.87).

Grain Yield

A maximum grain yield of 21.8 q/ha, *i.e., 114.3%* over local check was recorded by MNPL-2. Higher grain yield in this variety can be attributed to more number of pods per plant (34.5), number of seeds per pod (6.5), test weight (16.9 g). It is supported by the studies of Sharma *et al.* (1991). Besides this, the congenial crop growth conditions, greater adaptability and the efficiency to translocate photosynthates might have contributed to higher yields in this variety. MNPL-1 and MNPL-3 were recorded slightly lesser yields than MNPL-2 due to lower number of seeds per pod and lower test weight, respectively. Grain yield had a significant and positive correlation with number of pods, seeds per pod and plant height at phenotypic level (Sharma and Hore, 1994).

PRR-1 recorded the lowest yield (3.06 q/ha) due to poor crop growth, determinate nature of the variety and probably lesser adaptability to the climatic conditions of Chintapalle. This might have lead to less number of pods per plant and seeds per pod resulting in lesser yields.

CPRB-1 recorded the highest number of days (181) to maturity which might have reduced grain yields in corroboration with Sharma and Hore, 1994.

Among ricebean varieties MNPL-1, MNPL-2 and MNPL-3 have consecutively given higher yields during these two years and are highly suitable to high altitude and tribal area zone of Visakhapatnam district. Overall, yield difference of these varieties is due to number of pods per plant, number of seeds per pod, test weight, duration and determinate nature of the varieties taken for study.

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Research Note

Genetic Parameters, Correlations and Path Analysis in Finger Millet

Key Words : Finger Millet, Ragi, Correlations, Path Analysis

Finger millet [*Eleusine coracana* (L.) Gaertn] is one of the important millet crops grown for grain as well as fodder. The present study was undertaken to assess the variability and magnitude and direction of association of different traits along with cause and effect relationship in finger millet genotypes.

Nineteen genotypes of finger millet were evaluated in a randomized block design with 3 replications during *Kharif* 1999-2000 at Agricultural Research Station, Peddapuram, East Godavari District, Andhra Pradesh. Observations were recorded on 10 random, competetive normal looking plants in each genotype per replication for plant height, number of productive tillers, days to 50% flowering, ear head length, number of fingers per ear, days to maturity, harvest index, straw yield, 1000 seed weight and grain yield. Genotypic and phenotypic coefficients of variation (GCV and PCV) were estimated as per Burton (1952). Worked out correlations as per Falconer (1964) and path coefficients as per Dewey and Lu (1959).

Significant differences among the genotypes for the characters under study suggest the presence of variability in the material. The magnitude of PCV was higher than GCV indicating the influence of environment. Highest magnitude of PCV was observed for productive tillers (28.07) followed by fingers per ear (22.49), grain yield (20.92) and harvest index (17.17) and lowest in 1000 seed weight (5.32). The GCV was the highest for productive tillers (19.44) and lowest for 1000 seed weight (4.85) as in PCV. Both GCV and PCV values are more or less equal for the traits are less affected by environment. Wide range of differences between GCV and PCV suggest that the characters being remarkably masked by environment.

The heritability was high for all the traits except for straw yield and genetic advance as percentage of mean was high for fingers per ear, ear length, productive tillers, harvest index and grain yield. High heritability values coupled with high genetic advance as per cent of mean in fingers per ear, finger length, productive tillers suggested that the characters are under the control of additive gene action and breeder can go for direct selection.

Grain yield was positively and significantly associated with productive tillers (0.308), fingers per ear (0.306), length of ear head (0.329) and harvest index (0.796) suggesting that finger millet crop accumulates more dry matter as photo synthetically efficient C4 plant (Hanumantha Rao *et al.*, 1987). The association of grain yield with plant height, days to 50% flowering, days to maturity and 1000 seed weight is non-significant and positive indicating that plant growth stops once flowering commences. Plant height showed significant positive correlation with days to 50% flowering, days to maturity while showed

Table : Path coefficients - direct (underlined) and indirect effects, in finger millet genotypes

Name of characters	1	2	3	4	5	6	7	8	9	10
	Plant height	Days to 50% flowering	Number of productive tillers	Number of fingers/ ear	Main ear length	Days to maturity	Straw yield	Harvest index	1000 grain weight	Correlation with seed yield
Plant height	0.017	0.016	-0.007	-0.051	-0.006	-0.002	-0.048	-0.114	-0.011	-0.1867
Days to 50% flowering	0.006	0.044	0.009	-0.035	-0.013	-0.000	-0.067	-0.183	-0.002	0.3081*
Number of productive tillers	0.002	-0.007	-0.057	-0.015	0.036	0.001	-0.068	0.124	-0.011	-0.2483
Number of fingers/ear	-0.006	-0.010	0.006	0.143	-0.006	-0.000	0.065	0.017	-0.001	-0.1636
Main ear length	-0.002	-0.011	-0.039	-0.175	0.053	0.002	-0.011	0.010	-0.008	0.3294
Days to maturity	0.005	0.000	0.010	0.007	-0.017	-0.007	-0.026	0.171	-0.013	0.3061*
Straw yield	-0.027	-0.093	0.123	0.292	-0.019	0.005	0.031	-0.127	0.001	0.7964**
Harvest index	-0.002	-0.008	-0.007	0.002	0.001	0.001	-0.037	0.958	0.004	0.2955*
1000 grain weight	0.005	0.002	0.018	0.006	0.011	-0.002	-0.001	-0.114	-0.036	-0.0294

Residual effect = 0.363 * and ** = Significant at 0.05 and 0.01 levels of probability, respectively

significantly negative association with the fingers per ear.

Results of path coefficient analysis are furnished in Table. Highest positive and direct effect on seed yield was recorded for harvest index followed by number of fingers per ear indicating the importance of these traits in selection. Mishra (1996) also reported similar results. The direct effects of number of productive tillers, days to 50% flowering, days to maturity were negative. The indirect effects of plant height and fingers per ear were negative with most of the characters studied. From the correlation and path analysis, it can be concluded that number of fingers per ear and ear length, which recorded significant positive correlation with seed yield with high positive direct effects may be regarded for selection and yield improvement in finger millet.

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Research Note

Genetic Variability Studies in Genotypes of Mungbean [*Vigna radiata* (L.) Wilczek]

Key Words : Genetic Variability, Her tability, Genetic Advance, Mungbean

An experiment was conducted with 23 mungbean genotypes to study the genetic variability and genetic parameters during *kharif* season of 2002. Significant differences were observed among the genotypes for all agro-economic characters except pod length and number of seeds per pod. Higher estimates of genotypic coefficient of variation, heritability coupled with genetic advance were observed for number of clusters per plant, number of pods per plant and seed yield per plant, indicating the predominance of additive gene action and direct selction for these traits for improvement of seed yield in mungbean.

Mungbean is an important legume crop in India. It is gaining importance due to its wide adaptability, low input requirement and its ability to add 30-60 kg ha^{-1} of nitrogen to the soil. In order to improve the yield of mungbean through selection, it is essential to have a thorough knowledge of quantum of variability present in the germplasm and the extent to which the desirable traits are heritable. Therefore, the present experiment, was conducted to estimate the extent of genetic variability for yield and other yield traits.

The experimental material for the present investigation comprised 23 diverse mungbean genotypes. These were grown under randomized block design with three replications at the Field Experimentation Centre, Department of Genetics and Plant Breeding, Allahabad Agricultural Institute, Allahabad during *Kharif* 2002. Each genotype was raised in 1x3 m^2 plots with inter- and intra-row spacing of 30 cm and 15 cm, respectively. Recommended package of practices and plant protection measures were followed. The data were recorded on five randomly

Table 1 : Analysis of variance for 10 characters of mungbean

Source of variation	Days to 50% flowering	Plant height (cm)	No.of primary branches	No.of pods per plant	No.of clusters per plant	Pod length (cm)	Days to maturity	No.of seeds per pod	Test weight (g)	Seed yield per plant (g)
Replication	2.48	2.30	0.82	0.52	7.47	0.19	16.57	2.53	12.05	0.91
Genotypes	17.48**	208.83**	1.96*	265.05**	26.66**	1.26	51.51**	1.53	99.74**	35.71**
Error	1.50	2.68	0.67	23.09	1.79	0.17	4.06	0.61	7.01	6.23

*, ** Significant at 5% and 1% level respectively

Table 2 : Estimates of variabiltiy, heritability and genetic advance in mungbean genotypes

Characters	Mean	PCV	GCB	Heritability (%)	Genetic advance (% of mean)
Days to 50% flowering	36.84	7.04	6.20	77.6	11.24
Plant height (cm)	50.59	18.49	15.39	69.3	26.41
No. of primary branches	5.30	19.82	12.37	39.0	15.08
No. of pods per plant	40.70	25.03	22.07	77.7	40.08
No. of clusters per plant	9.70	32.75	29.69	82.2	55.49
Pod length (cm)	7.43	9.87	8.12	67.6	13.74
Days to maturity	63.74	7.00	6.24	79.6	11.47
No. of seed per pod	11.06	8.67	5.02	35.5	5.97
100-seed weight (g)	3.63	16.96	15.31	81.5	28.47
Seed yield per plant (g)	16.34	24.52	19.18	61.2	30.90

selected plants in each plot for 10 characters including seed yield per plant. The mean data over three replications were used for statistical analysis. The genetic parameters were estimated following Burton (1952) and Johnson *et al.* (1955).

The analysis of variance revealed that the genotypes differed significantly for all the characters studied except pod length and number of seeds per pod (Table 1), indicating the presence of substantial genetic variability among the genotypes. In general, the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) but the difference was wide for the characters number of primary branches per plant and seed yield per plant indicating greater role of environment on the expression of these traits. Number of clusters per plant, number of pods per plant and seed yield per plant exhibited high GCV and suggested that substantial amount of genetic variability existed in the genotypes for these traits, in accordance with Loganathan *et al.* (2001).

GCV together with the estimates of heritability would give a clear picture of the extent of advance to be expected by selection (Burton, 1952). High GCV combined with high heritability was registered for number of clusters per plant, number of pods per plant and seed yield per plant. Heritability estimates when calculated together with genetic advance provides the real progress in predicting resultant effect of selection (Johnson *et al.* 1955). In the present study, high heritability combined with high genetic advance (as percentage of mean) was observed for number of clusters per plant, number of pods per plant and seed yield per plant, in consonance with Naidu *et al.* (1991) and Vikas *et al.* (1998) and suggested that these characters were controlled by additive gene effects and phenotypic selection for these traits may be effective.

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Research Note

Evaluation of Fullsib Progenies for Genetic Enhancement of Seed Yield in Greengram [*Vigna radiata* (L.) Wilczek]

Key Words : Greengram, Seed Yield, Fullsib

Greengram is one of the important grain legumes grown in many regions of India and known for its high nutritive value, high protein content and low flatulence. For the evolution of new varieties, hybridization and selection have been the most effective tools for combining the desired attributes from different sources. In contrast to conventional pedigree breeding, random mating population could produce large amount of genetic variability. This can be maintained by recurrent mating and the population is improved by selection. Hence, an attempt was made to generate large reservoir of variation with an idea of selecting the best plants for advanced generations.

Experiment was conducted at S. V. Agricultural College, Tirupati during *rabi* 2002-2003. The F_3 generation of the cross LGG 410 x LGG 450 was utilised for generating fullsib progenies by making pair wise selection of one male and one female plant respectively. Thus 30 fullsib progenies were developed. The selfed seed obtained from F_2 generation was designated as the source seed for F_3 bulk population. The fullsib progenies and the corresponding F_3 bulk population were sown in a randomized block design with three replications. Each fullsib progeny consisted of three rows of 3m in length, with inter-and intra -row spacing of 45 cm and 15 cm, respectively. Data were recorded on nine quantitative traits *viz.*, plant height, clusters per plant, pods per plant, pods per cluster, seeds per pod, pod length, 100-seed weight, harvest index and seed yield per plant and were analysed to estimate mean and variance of 30 fullsib progenies.

The presence of high variability for yield contributing characters is an essential pre-requisite for any population improvement programme in the crop plants. In the present study, many progenies with higher mean and variance for the important characters were observed (Table 1). Among the 30 fullsib progenies, none of them was found to be taller in comparison with the mean height of base population (37cm). The variance observed for plant height was high in fullsib progenies than their corresponding F_3 bulk population indicating the scope for selection in fullsib progenies for plant height. Twenty seven fullsib progeny families showed increased variance over base population.

Cluster number of the fullsib progenies showed increase over the mean value. Six progeny families *viz.,* FS 6, FS 14, FS 17, FS 20, FS 24 and FS 25 exhibited high mean values

Table : Mean performance and variance for eleven characters in 30 fullsib progenies of LGG 410xLGG 450 of greengram

Full sib number	50 per cent flowering	Days to maturity	Plant height (cm)	Clusters per plant	Pods per plant	Pods per cluster	Seeds per pod	Pod length (cm)	100 seed weight (g)	Harvest index (%)	Grain yield (g)
1	37.00	68.00	22.82 (22.68)	7.25 (7.28)	37.28 (204.76)	4.86 (2.36)	8.92 (1.95)	6.84 (0.39)	4.04 (0.063)	21.95 (6.00)	14.70 (41.78)
2	49.00	69.33	28.76 (25.78)	7.08 (4.43)	42.69 (116.85)	8.72 (2.49)	7.98 (3.84)	6.47 (0.27)	3.96 (0.024)	22.14 (2.50)	14.04 (26.04)
3	47.33	71.00	27.73 (22.91)	7.50 (6.84)	46.69 (203.95)	6.05 (2.99)	8.16 (1.94)	7.09 (0.50)	3.96 (0.027)	22.31 (5.20)	14.25 (28.34)
4	46.00	69.00	28.90 (22.90)	6.78 (4.11)	49.26 (104.01)	4.86 (2.51)	7.51 (2.98)	5.47 (0.48)	4.02 (0.036)	22.57 (2.58)	13.08 (15.11)
5	41.66	67.33	29.13 (29.26)	5.90 (3.63)	47.52 (164.50)	5.75 (3.01)	11.52 (3.93)	6.97 (0.28)	3.97 (0.045)	23.00 (5.26)	18.85 (42.61)
6	43.33	70.33	26.24 (26.54)	8.30 (7.41)	47.41 (142.10)	6.79 (2.77)	10.55 (2.24)	6.91 (0.22)	3.79 (0.038)	22.48 (4.12)	17.99 (40.93)
7	46.66	69.60	23.12 (30.38)	8.13 (9.80)	46.43 (93.84)	7.72 (1.10)	10.32 (2.51)	7.24 (0.33)	3.36 (0.280)	22.84 (2.54)	15.04 (23.36)
8	47.33	70.00	25.68 (33.52)	8.84 (4.13)	41.08 (85.62)	5.80 (0.92)	6.41 (2.42)	6.98 (0.24)	4.01 (0.061)	23.18 (1.75)	14.09 (21.26)
9	47.00	73.33	26.30 (28.08)	6.57 (5.18)	36.21 (104.37)	10.61 (3.15)	8.45 (1.37)	6.29 (0.54)	3.26 (0.124)	22.25 (1.72)	10.35 (7.20)
10	51.33	70.00	25.24 (34.23)	7.72 (6.37)	41.68 (128.31)	6.75 (1.27)	8.73 (1.79)	6.68 (0.45)	3.89 (0.067)	22.77 (3.35)	13.03 (14.62)
11	45.00	68.33	27.70 (25.02)	6.98 (4.17)	40.74 (90.52)	4.45 (3.02)	8.49 (3.25)	7.19 (0.29)	3.92 (0.096)	22.33 (6.27)	13.49 (32.68)
12	45.66	71.66	28.55 (24.12)	7.89 (5.77)	37.78 (85.59)	5.57 (2.28)	8.45 (1.62)	7.70 (0.43)	4.20 (0.076)	22.86 (4.24)	13.10 (17.59)
13	51.33	75.00	24.30 (28.43)	6.31 (2.79)	38.45 (119.53)	6.38 (6.23)	8.78 (2.03)	7.23 (0.61)	3.55 (0.076)	22.42 (4.28)	11.85 (15.19)
14	46.00	71.66	28.66 (18.17)	10.86 (10.57)	44.90 (34.72)	5.76 (3.84)	10.46 (2.06)	7.70 (0.31)	3.93 (0.061)	23.64 (3.61)	17.62 (24.20)
15	48.33	73.33	29.54 (23.49)	7.59 (4.39)	32.96 (71.02)	5.01 (4.05)	9.63 (2.31)	6.76 (0.27)	4.06 (0.105)	23.73 (2.80)	17.36 (25.63)
16	50.66	73.00	28.22 (24.98)	7.80 (6.19)	40.03 (71.02)	5.43 (1.87)	10.32 (2.25)	6.79 (0.10)	3.86 (0.105)	23.04 (1.57)	13.53 (17.23)
17	43.00	67.66	25.69 (23.11)	8.43 (4.89)	33.46 (180.34)	5.82 (3.16)	8.76 (1.52)	6.44 (0.22)	3.67 (0.050)	22.52 (2.86)	12.74 (45.89)
18	42.66	68.00	30.32 (34.09)	9.32 (8.86)	57.47 (289.03)	6.10 (4.62)	9.29 (2.42)	7.08 (0.17)	3.79 (0.059)	23.61 (4.02)	16.54 (48.59)
19	45.66	72.00	28.42 (24.00)	8.25 (5.82)	42.10 (100.78)	6.16 (3.53)	10.99 (2.16)	7.37 (0.33)	3.56 (0.098)	24.15 (8.08)	18.35 (14.11)
20	44.00	69.00	25.81 (18.96)	8.43 (1.48)	51.00 (132.22)	5.46 (6.68)	10.08 (1.99)	6.68 (0.21)	2.91 (0.167)	23.03 (3.08)	15.82 (15.12)
21	46.00	70.33	26.21 (20.69)	8.24 (10.08)	45.79 (88.66)	6.65 (5.01)	10.90 (1.25)	6.96 (0.15)	3.40 (0.061)	23.30 (1.32)	13.66 (16.94)
22	44.66	66.33	20.73 (16.06)	6.26 (4.18)	35.27 (37.35)	4.50 (3.33)	10.02 (2.01)	6.35 (0.67)	3.31 (0.110)	22.36 (1.16)	16.42 (8.64)
23	45.00	69.00	24.82 (25.03)	5.42 (8.30)	53.44 (137.96)	7.38 (10.61)	8.33 (3.81)	6.90 (0.24)	3.57 (0.081)	23.37 (2.54)	11.65 (12.69)
24	47.00	70.66	33.30 (25.60)	11.33 (15.67)	51.47 (169.26)	7.01 (5.57)	10.73 (2.87)	6.55 (0.25)	3.93 (0.088)	23.85 (3.12)	15.32 (31.76)
25	45.33	68.00	27.07 (40.10)	8.60 (7.96)	45.46 (116.89)	6.38 (5.22)	8.04 (5.20)	6.86 (0.12)	4.26 (0.086)	22.80 (2.16)	19.12 (22.19)
26	47.33	70.66	29.33 (26.62)	6.48 (5.14)	27.59 (143.19)	5.86 (6.12)	8.00 (3.51)	7.16 (0.40)	3.69 (0.090)	21.75 (5.72)	14.59 (15.21)
27	44.66	71.33	25.82 (19.19)	6.38 (3.13)	56.96 (264.00)	6.66 (10.72)	7.89 (2.12)	6.37 (0.24)	3.63 (0.080)	24.79 (1.39)	9.56 (12.70)
28	46.33	69.00	26.95 (15.76)	6.72 (3.13)	51.28 (80.80)	6.62 (7.15)	9.43 (2.46)	7.06 (0.05)	3.72 (0.079)	23.23 (2.40)	15.86 (18.28)
29	45.66	74.00	27.59 (26.69)	7.75 (4.27)	36.60 (108.99)	4.83 (1.81)	8.08 (0.95)	6.73 (0.10)	4.06 (0.102)	22.30 (3.29)	16.58 (33.43)
30	50.33	75.00	23.33 (13.47)	7.01 (3.52)	34.93 (35.18)	6.56 (2.35)	9.06 (1.81)	6.89 (0.10)	5.59 (0.067)	21.44 (3.02)	12.44 (6.34)
F_1	43.83	69.08	37.00 (17.45)	8.25 (5.74)	38.29 (78.94)	4.62 (2.81)	7.54 (2.01)	6.96 (0.19)	3.62 (0.06)	22.0 (2.34)	10.52 (13.50)
SE (m) for full sibs	2.09	1.05	0.83	0.25	1.05	0.17	0.08	0.14	0.03	0.39	0.44
SE (m) for F_3 bulk	0.35	0.45	0.35	0.60	0.42	0.42	0.48	0.15	0.03	0.64	0.33

Values in parentheses denote variances

than F_3 bulk population. Variance values were also high in 14 progeny families over base population. High values of clusters per plant as well as high variance was noted for FS 24, FS 14, FS 25, FS 21 and FS 6. These could be used for selection to increase the number of clusters per plant.

Twenty one progeny families showed higher values for pod number over base population. Full sib progenies *viz.*, FS18, FS 27, FS 23; FS 24 and FS 20 recorded higher values of pod number (>50 per plant). Twenty five full sib progenies exhibited high variance values over base population (79.84) among which FS 18, FS 28, FS 20, FS 5, FS 25, FS 24 and FS 19 exhibited high mean value as well as variance for pod number as also reported by Jayaprada (2002).

Among 30 full sib progenies, 28 progenies showed high mean performance over base population for pods per cluster (4.62). Nineteen full sib progenies showed high variance over base population (2.81). The progenies *viz.*, FS 27, FS 23, FS 13, FS 28, FS 24, FS 12, FS 20, FS 17, FS 18, FS 13 and FS 9 recorded higher values for mean as well as variance for pods per cluster. Hence, these progenies could be promising for obtaining genotypes with high yield potential.

A mean number of 7.54 seeds per pod was observed in base population. On contrary, 28 fullsib progenies showed higher number of seeds per pod over the base population. Twenty full sib progenies showed high variances over base population (2.01) for seeds per pod. The fullsib progenies *viz.*, FS 28, FS 26, FS 23, FS 21, FS 20, FS 19, FS 18 and FS 2 exhibited high mean value and variances for seeds per plant.

The mean pod length of F_3 bulk population was 6.69 cm. Twelve progenies showed higher mean values and eighteen progenies registered higher variance values for pod length. The fullsib progenies, *viz.*, FS 5, FS7, FS 8, FS 11, FS 12, FS 13, FS 14, FS 19 an FS 26 showed high values for both mean and variances. Hence, these could be used for selection to increase the pod length character.

The values of 100-seed weight ranged from 2.91 g to 5.59 g among the fullsib progenies. Twenty three full sib progenies exceeded the mean of base population (3.62 g). Nearly half of the progenies exhibited higher variance values for 100-seed weight. The full sib progenies *viz.*, FS 11, FS 13, FS 15, FS 16, FS 24, FS 25, FS 29 and FS 30 showed high mean as well as high variance values for 100-seed weight. Patil and Shinde (1995) observed low magnitude of variance for 100-seed weigh in mungbean.

High harvest index was recorded in 27 fullsib progenies among which 24 fullsib progenies exceeded the variance of F_3 bulk population. The progenies *viz.*, FS 3, FS 5, FS 11, FS 12, FS 18, FS 19, FS 24 and FS 19 recorded high mean as well as variances in fullsib progenies over base population. Madhavilatha and Lakshmikantha Reddy (2001) observed high variances for harvest index in mungbean as was reported in the present study. Seed yield was higher in twenty eight fullsib progenies compared to mean of the base population (10.52 g). The variances for fullsib progenies were found to be higher than the base population (13.50). The progenies *viz.*, FS 4, FS 5, FS 6, FS 14, FS 15, FS 18, FS 19, FS 20, FS 25, FS 28 and FS 29 recorded high values for both yield as well as variances. Selection in these progenies will produce greengram genotypes with high yield potential in agreement with the earlier report of to Jayaprada (2002) in mungbean.

Seven fullsub progenies *viz.*, FS 18, FS 24, FS 5, FS 6, FS 14, FS 19 and FS 25 were selected based on yield performance and other characters under study.

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Research Note

Genetic Variability in New Plant Types of Blackgram [*Vigna mungo* (L.) Hepper]

Key Words : Blackgram, Variability, Urad

Two new plant types with changed bearing habit *viz.,* main stem bearing (normal cluster along with additional pods in the axil of main stem) and sympodial bearing (more number of pods per cluster with indeterminate bearing with in the cluster) have been developed at the Regional Agricultural Research Station (RARS), Lam, Guntur with a potential to achieve quantum jump in yield by 40-60%.

Understanding of the nature of genetic variability in two types of bearing habits compared to normal bearing habit in blackgram will help in selection process aimed at achieving quantum jump in blackgram yields.

Thirty genotypes of blackgram (Table 1) normal bearing (10 genotypes), main stem bearing (10 genotypes) and sympodial bearing (10 genotypes), were selected for the study.

The experiment was laid out during *rabi,* 1997-98 at Regl. Agril. Research Station, Lam, Guntur in a randomized block design with three replications. Each genotype was sown in six rows of 4.0 m length with a spacing of 30 cm between rows and 10 cm within the row. Uniform population was maintained in all the entries. Observations were recorded for days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, harvest index, leaf area index, peduncle length and 100 seed weight (g) and means were statistically analysed.

The analysis of variance revealed significant differences among the genotypes and also within each bearing group for all the characters studied. In pooled analysis the

Table 1 : List of the blackgram genotypes of different bearing habits

Sl.No.	Normal bearing	Sl.No.	Main stem bearing	Sl.No.	Sympodial bearing
1	LBG 693	11	LBG 685	21	LBG 20 x (UG 201 x 400)
2	LBG 703	12	LBG 402 x (LBG 17 x CKM)	22	LBG 611 x (UG 201 x 400)
3	LBG 708	13	LBG 676 x T9	23	LBG 17 X (UG 201 x 400)
4	LBG 709	14	LBG 676 x BM	24	LBG 637 x LBG 17
5	LBG 107	15	(LBG 676 x LBG 17) x LBG 676	25	LBG 637 x LBG 402
6	PBG 206	16	(LBG 676 x LBG 402) x LBG 676	26	(LBG 637 x LBG 17) x LBG 637
7	LBG 17	17	LBG 402 x (PDU 3 x CKM)	27	LBG 402 x (LBG 17 x 400)
8	LBG 402	18	LBG 632 x T9	28	(LBG 637 x SK-1-1) x LBG 637
9	LBG 22	19	LBG 632 x LBG 17	29	LBG 617 x LBG 402
10	LBG 611	20	LBG 685 x LBG 22	30	LBG 617 x SK-1-1

Table 2 : Estimates of PCV (%), GCV (%), h^2 (%) and genetic advance (GA) in different plant types of blackgram

Characters	Pooled analysis (%)				Normal bearing types (%)				Main stem bearing types (%)				Sympodial bearing types			
	PCV	GCV	h^2	GA	PCV	GCV	h^2	GA	PCV	GCV	h^2	GA	PCV	GCV	h^2	GA
Days to 50% flowering	6.83	6.69	96.10	5.55	2.39	2.05	73.04	4.57	6.98	6.82	95.49	5.56	5.11	4.94	93.54	3.84
Days to maturity	2.61	2.53	93.60	4.37	1.89	1.76	87.06	2.91	1.49	1.34	80.10	2.15	2.98	2.91	95.44	4.99
Plant height (cm)	19.83	18.76	89.59	20.86	17.56	16.68	90.28	11.84	11.53	10.45	82.13	11.28	23.18	21.49	86.04	20.42
No.of branches per plant	16.41	12.37	56.83	0.52	15.71	10.83	47.89	0.45	15.76	10.78	46.81	0.41	13.82	9.58	48.00	0.34
No.of clusters per plant	22.06	19.18	75.58	4.44	23.51	21.12	80.69	5.62	20.64	17.97	75.82	4.15	14.45	10.09	31.42	4.08
Peduncle length (cm)	27.46	25.69	87.51	3.53	14.10	10.71	57.71	1.37	14.03	9.97	50.54	1.23	20.05	17.39	75.32	1.51
No.of pods per cluster	17.26	16.40	90.25	1.30	12.43	10.04	77.15	1.59	6.84	4.88	50.84	0.82	8.02	6.07	57.30	0.64
No.of pods per plant	16.76	14.89	78.88	9.34	20.01	18.82	88.53	10.78	11.34	7.96	49.32	4.25	10.12	7.84	59.97	4.56
Pod length (cm)	6.84	6.21	82.61	0.59	6.34	5.12	65.08	0.39	6.03	5.38	79.62	0.52	2.92	2.15	54.13	0.52
No.of seeds per pod	6.24	6.71	57.03	0.52	6.81	5.23	58.98	0.57	5.08	3.92	59.39	0.45	6.39	4.37	46.76	0.44
100 seed weight (g)	8.05	6.99	75.33	0.60	9.82	8.76	79.52	0.77	7.62	6.68	76.84	0.58	7.11	5.97	70.48	0.50
Total drymatter (g)	20.26	17.96	78.55	15.85	13.29	11.20	71.12	10.89	14.52	13.59	36.44	5.28	18.19	15.85	75.84	11.29
Harvest index	29.37	25.56	75.75	9.71	16.14	12.88	63.64	3.67	27.10	20.89	59.40	7.08	28.46	24.93	76.71	11.20
Leaf area index	12.98	12.13	87.39	0.53	9.74	8.75	80.64	0.38	15.34	14.79	93.11	0.68	12.55	11.35	81.78	0.45
Seed yield per plant (g)	20.12	18.39	83.55	3.41	20.35	18.67	84.13	3.39	20.36	18.67	83.98	3.61	20.96	19.22	84.05	3.50

characters peduncle length, harvest index, number of clusters per plant, seed yield per plant, number of pods per cluster and number of pods per plant exhibited sufficient variability, high heritability coupled with low to moderate genetic advance (Table 2). Total dry matter and plant height have high variability, high heritability coupled with high genetic advances (Renganayaki and Sreerangasamy, 1993).

In normal bearing group high variability, heritability and moderate to high genetic advance were recorded by number of pods per plant and total dry matter (Kshir Sagar and Deore, 1990 and Koteswara Rao, 1990) while in main stem bearing the characters harvest index, number of clusters per plant and seed yield per plant recorded high variability and heritability. Harvest index and plant height showed high heritability coupled with moderate genetic advance (Choulwar *et al.*, 1997 and Ganeshram *et al.*, 1997) and in sympodial bearing group high variability, heritability and moderate to high genetic advance were noticed for the yield components *viz.*, plant height, harvest index and total dry matter (Chakraborthy and Hazarika, 1997) indicating that these traits are under the control of additive gene action and possibile for the improvement of these traits.

These two new bearing types *viz.*, main stem bearing and sympodial bearing can be transferred to the existing cultivars which inturn increase total pod number and enhance the harvest index without reducing the biological yield.

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Research Note

Variability Studies in Drought Resistant Cultures of Rice

Key Words : Drought Resistance, Variability, Rice

Rice, the most important food crop in India occupies 44.0 million hectares, the largest rice area in the world. India achieved self-sufficiency in rice in 1977 and to maintain self-sufficiency, annual production needs to increase by 2 million tonnes every year. Yield for rice under rainfed conditions in India are low, compared with those of irrigated rice yields. Hence 24 drought resistant cultures collected from various locations in Tamil Nadu were screened to find out the extent of variability and scope for improvement in yield per plant.

Twenty three drought resistant cultures from Tamil Nadu along with check variety IR 64 were raised at Agricultural College and Research Institute, Killikulam during 2003-2004 in randomized block design with three replications. Three plants in every genotype were randomly selected in each replication and observations were recorded on plant height, number of productive tillers per plant, flag leaf length, flag leaf width, panicle length, number of grains per panicle, dry matter production, harvest index, root dry weight, root volume, 100 grain weight, root length and yield per plant. GCV and PCV were worked out according to Burton (1952). The procedure by Hanson *et al.* (1956) was followed to estimate the heritability in the broad sense and genetic advance as percentage of mean was worked out as per Lush (1949) and Johnson *et al.* (1955).

The variability estimates of genotypic and phenotypic variances, genotypic and phenotypic coefficients of variation, heritability and genetic advance are presented in Table.

The phenotypic variance was higher than fhe genotypic variance, indicating the effect of environment on different characters. The genotypic and phenotypic variance were very high (324.11 and 473.64) for dry matter production, number of filled grains per panicle (179.52 and 271.93) and root volume (90.32 and 104.77). Other traits that have recorded high genotypic and phenotypic variance were plant height (82.71 and 145.53), harvest index (61.00 and 131.33) and yield per plant (55.05 and 75.61). Lowest genotypic and phenotypic variance were recorded by the trait 100-grain weight (0.10 and 0.14).

High GCV was observed for the traits, root dry weitght, root volume, dry matter production and yield per plant. Singh *et al.* (2000) also observed high GCV for yield per plant. Moderate GCV was observed for the traits, number of filled grains per panicle, flag fleaf length, harvest index, number of tillers per panicle and 100 grain weight.

Table : Variability studies in drought resistant cultures of rice

Character	Mean	Variance		GCV	PCV	Heritability (%)	GA	GA (%) of mean
		Genotypic	Phenotypic					
Plant height	122.10	82.71	145.53	7.44	9.87	56.84	14.11	11.56
Number of tillers	13.13	2.41	8.57	11.83	22.29	28.18	1.69	12.94
Flag leaf length	33.94	37.50	64.86	18.04	23.72	57.82	9.59	28.26
Panicle length	23.07	2.55	5.41	6.92	10.08	47.15	2.25	9.79
Number of grains	67.58	179.52	271.93	19.82	24.40	66.02	22.42	33.18
Drymatter	59.33	324.11	473.64	30.34	36.67	68.43	30.67	51.70
Harvest index	44.12	61.00	131.33	17.70	25.97	46.45	10.96	24.85
Root dry weight	7.18	11.97	17.93	48.17	58.97	66.75	5.82	81.08
Root volume	20.48	90.32	104.77	46.39	49.96	86.21	18.17	88.73
100 grain weight	2.86	0.10	0.14	11.19	13.06	73.45	0.56	19.77
Root length	15.49	5.49	10.83	15.12	21.24	50.66	3.43	22.17
Yield per plant	25.15	55.05	75.61	29.49	34.56	72.81	13.03	51.84

GCV = Genotypic coefficient of variation PCV = Phenotypic coefficient of variation GA = Genetic advance

PCV was found to be high for root dry weight, root volume, dry matter production, yield per plant, harvest index, number of filled grains per panicle, flag leaf length, number of tillers per plant and root length. High level of variability observed in the experiment indicates that genotypes under study had diverse genetic base.

High heritability estimates were observed for root volume, 100 grain weight, yield per plant, dry matter production,root dry weight and number of filled grains per panicle as was also observed by Kishore (1994) and Banerjee (1993). This indicates that traits were less influenced by environmental fluctuations and may respond to selection satisfactority for their further improvement.

The heritability value was moderate for flag leaf length, plant height, root length, panicle length and harvest index, suggesting there by, that these characters could be manifested by the environmental influence.

The genetic advance values should also be considered simultaneously as high heritability combined with high genetic advance is likely to result in maximum genetic gain during selection (Johnson *et al.,* 1955). In the present material, the traits drymatter production and number of filled grains per panicle have high genetic advance. The GA as percentage of mean was found high for root volume, root dry weight, yield per plant, drymatter production, number of filled grains per penicle, flag leaf length, harvest index and root length. High GA was also observed by Chaudhary *et al.* (1973) for grains per penicle. This indicates the preponderance of additive gene effect for above traits which will be useful for selection in early generation.

High heritability coupled with moderate genetic advance was noticed for root volume and yield per plant, which may be influenced by the additive gene effects partially. High heritability and low genetic advance with moderate to high genetic gain was observed for the traits, root dry weight and 100 grain weight. This indicates the involvement of additive and non-additive gene actions. Hence, selection followed by intermating to obtain superior transgressive segregants would help in improvement of these traits.

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Research Note

Effect of EMS on Induction of *In Vitro* Variability in Rice

Key Words : Ethyl Methane Sulphonate, In Vitro Culture, Rice, Variability

Drought is a real concern and yield limiting factor on almost half of the world's 70 million hectares of rainfed rice. Hence, breeding efforts should concentrate on varieties with the potential to minimize yield losses under unfavourable conditions such as drought. Rice being a self-pollinated crop much variability is not present. Therefore, for enlarging the variability and to increase the scope of selection for yield potential, induced mutagenesis has been resorted to (Nallathambi and Guruswamy Raja, 1990). Mutation breeding along with *in vitro* techniques has been considered as a promising tool for the creation of variability in crop plants during recent times. Present study was conducted with this view to find out the effect of EMS on induction of variability *in vitro* in rice.

This experiment was carried out at Agricultural College and Research Institute, Killikulam under laboratory conditions. Two genotypes, PMK 1 and Norungan were taken and callus induction was done using seed as explant on MS medium. For both the genotypes, 21-d-old subcultured callus, which has grown to considerable size, was selected. The EMS solution was prepared with the concentration of 2 mM, 4 mM, 6 mM, 8 mM, and 10mM @ 50 ml in each concentration. Along with these five concentrations, a check was maintained with sterilized distilled water. The preparation of EMS solution was done under aseptic conditions. Callus selected for treatment was transferred to the EMS solution. Transfer of callus was done under aseptic condition. Transfer of callus was done for all five concentrations including distilled water as control. Period of treatment of callus with EMS solution was four hours. During the period of treatment, conical flask was shaken frequently to have uniform treatment with callus. Throughout the period of treatment, the fan was switched on to avoid contamination. After four hours of treatment, the treated callus was carefully washed with sterilized distilled water for 6-7 times to remove the traces of EMS

Table 1 : ANOVA for *in vitro* mutagenesis

Soureces of variation	df	Volume	Diameter	Weight
PMK 1				
Total	35	0.287	0.175	0.030
Treatment	5	0.763**	0.546**	0.042
Error	30	0.207	0.114	0.028
Norungan				
Total	41	0.482	0.166	0.237
Treatment	5	1.939**	0.646**	0.284
Error	36	0.280	0.100	0.231

* Significance at 5% level ** Significance at 1% level

Table 2 : Effect of EMS solution on Callus weight, Callus volume and Callus diameter

Treatment	Callus weight						Callus volume					
	PMK 1			Norungan			PMK 1			Norungan		
	Mean	%over control	Percetage increase or decrease over control	Mean	%over control	Percetage increase or decrease over control	Mean	%over control	Percetage increase or decrease over control	Mean	%over control	Percetage increase or decrease over control
Control	117.36	100.00	---	93.19	100	---	1.004	100.0	---	1.467	100.0	---
2 mM	53.45	45.55	-54.45	59.02	63.34	-36.66	0.598	59.60	-40.40	0.325	22.14	-77.86
4 mM	58.44	49.80	-50.20	266.35	285.82	185.82	0.609	60.65	-39.35	1.754	119.85	19.85
6 mM	94.63	80.64	-19.36	89.50	96.05	-3.95	1.192	118.68	18.68	0.724	49.37	-50.63
8 mM	155.11	132.16	32.16	157.87	169.42	69.42	1.249	124.35	24.35	0.898	61.24	-38.76
10 mM	83.44	71.09	-28.91	242.72	260.47	160.47	0.293	29.19	-70.81	1.081	73.71	-26.29

(contd...........)

solution. After washing thoroughly with sterilized distilled water, callus was moved carefully to already prepared callus proliferation medium. After 21-days, callus was transferred from callus proliferation medium to the regeneration medium. The tubes were incubated in culture room under controlled environment with a temperature of 25 2°C and 70 per cent relative humidity. Callus weight, callus volume and callus diameter were recorded on 21 days of growth and the data were subjected to statistical analysis.

The analysis of variance (Table 1) showed that both the genotypes had a significant difference among the treatments for callus volume and diameter.

Compared to PMK 1, Norungan gave best results with increased percentage of callus weight, observed at three concentrations namely 4 mM, 8 mM and 10 mM EMS dose. While the treatment of EMS with PMK 1 gave increased per cent of callus weight over control at 8 mM concentration only (Table 2). Khan *et al.* (1999) treated the callus of sugarcane with 2 mM solution of N-nitroso-N-methylurea (MNH) and gamma rays (10 and 15 GY) and observed an inhibition of callus growth in relation to control in every treated culture and reduction in fresh-weight gain ranged from 42-91%.

When the mutagenic treatments of PMK 1 and Norungan were compared (Table 2), an increase in callus volume of 24.35% over control was obtained at 8 mM treatment in PMK 1 and olny 19.85% increase over control was obtained at 4 mM treatment in Norungan. Hence, Norungan may be concluded as more vulnerable to mutagenic exposure.

Comparing effect of EMS on callus diameter of PMK 1 and Norungan (Table 2), it can be understood that with PMK 1, EMS caused only a decreased percentage of callus diameter over control and with Norungan, except 4 mM

(contd....Table 2)

	Callus diameter					
	PMK 1			Norungan		
Treatment	Mean	%over control	Percetage increase or decrease over control	Mean	%over control	Percetage increase or decrease over control
Control	1.270	100.00	---	1.442	100.0	---
2 mM	1.085	85.49	-14.51	0.959	66.51	-33.49
4 mM	1.071	84.36	-15.64	1.587	110.09	10.09
6 mM	1.175	92.52	-7.48	1.222	84.73	-15.27
8 mM	1.240	97.77	-2.23	1.000	69.35	[illegible]
10 mM	0.435	34.25	-65.75	1.142	79.17	[illegible]

dose, all other doses caused a decrease in callus diameter over control.

Pooled performance for callus weight, callus volume and callus diameter, both in PMK 1 and Norungan showed that it is not following any regular pattern. EMS had some antagonistic effect on callus cultures was clearly exhibited. Since maximum recovery of callus was obtained at 8 mM dose of EMS for PMK 1, while creating variability *in vitro,* the dose can be fixed around 8 mM. While considering the *in vitro* treatment of EMS with Norungan, maximum recovery of callus was obtained at 4 mM dose. Hence the dose can be fixed around 4 mM, for *in vitro* mutagenesis with Norungan. Thus induction of *in vitro* mutagenesis through EMS is clearly genotype dependent. When EMS treated callus from both PMK 1 and Norungan were transferred to regeneration medium, few calluses produced embryogenic and rhizogenic callus. Later they developed into shoot and then died.

In conclusion, it can be found that induction of chemical mutagenesis with EMS, 8 mM for PMK 1 and 4 mM for Norungan, was more productive and expected to throw more variants. It is hard to screen the variants through *in vitro* mutagenesis due to difficulty in regeneration. Hence, it is recommended for further refinement in standardization of regeneration technique to recover better plant type suitable for drought ecosystem.

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Research Note

Correlation and Path Analyses of Yield and Yield Components in The Commercial Cultivars of Cassava in Andhra Pradesh

Key Words : Correlations, Path Analysis, Cassava

The need to achieve high yield potential in cassava is a necessity. Hence, this study was taken up to measure mutual association of characters to yield through correlations and direct and indirect effects through path coefficient analysis.

Nineteen commercial accessions of cassava *viz.*, Malabar, H 1310, H-57, H-123/74, H2087, H-97, H2371, H43, H14/75, H3641, Burma, H1350, H1175, H975, H17/78, H86, H2304, H1687, H5/78 were studied in randomized block design with four replications with a plot of size of 5.5x5.5m^2 with 24 plants at inter-and intra-row spacing of 110cmx110cm. Observations were recorded on plant height, stem girth, tubers per plant and tuber length. The extent of variation among characters was studied and correlation coefficients were estimated as per Singh and Choudhary (1979) and path coefficient analysis following Wright (1921).

The results of correlation coefficients are presented in Table-1. Plant height recorded positive but non-significant correlation with tuber yield. Tubers per plant and tuber length had strong positive correlation with tuber yield at phenotypic and genotypic levels. Similar results of positive correlation of tubers per plant to tuber yield were obtained by Magoon *et al.* (1972) and Biradar *et al.* (1978).

Results of path coefficient analysis are furnished in Table 2. Tuber length contributed high positive and direct effect on tuber yield on cassava followed by tubers per plant. Rekha *et al.* (1991) reported strong positive direct effect of tubers per plant on tuber yield. The direct effect of plant height on tuber yield is non-significant and indirect effect through other traits is negative and non-significant.

From the correlation and path analysis studies it can be concluded that number of tubers per plant and tuber length recorded

Table 1 : Correlation coefficients among the characters and yield of Cassava

	Stem grith	Tubers per plant	Tuber length	Tuber yield
Plant height	0.212	-0.250	-0.289*	-0.147
Steem girth		-0.229	-0.281*	-0.180
Tubers per plant			0.102	0.283*
Tuber length				0.397**

* Significant at 5% ** Significant at 1%

Table 2 : Direct and indirect effects of various characters on tuber yield in cassava

	Plant height	Stem girth	Tubers per plant	Tuber length
Plant height	0.03056	-0.00955	-0.06066	-0.10723
Stem girth	0.00648	-0.04504	-0.05554	-0.08556
Tubers per plant	-0.00765	0.01032	0.24249	0.03775
Tuber length	-0.00884	0.01040	0.02470	0.37058

Underline values are direct effects on the yield

significant and positive direct effects and may be regarded as prime characters in selection for yield improvement.

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Research Note

Apomixis in Rice

Key Words : Rice, Apomixis, Apomictic Seed

The phenomenon of apomixis makes it convenient to raise a second generation from F_1 hybrid without any yield reduction or to repeat the same high yielding performance of F_1 generation. It is a mechanism through which seeds of F_1 hybrid, equivalent to the vegetative propagation, are available to the farmers. Apomictic seeds also form a suitable answer to problems like terminator seeds.

In the present investigation apomixis was studied in rice apomictic populations I, II, III and IV by calculating frequency of germinating seeds with more than one plumule/seedling and also the frequency of seeds with more than one embryo.

For counting the number of seeds with more than one plumule (Fig 1) 300 seeds were put on the moistened filter paper inside the pertridish in each of the 3 replicates, in incubator at 30°C for 16 hr. The germinating seeds were counted on 3rd, 5th, 7th and 10th day. The percentage of twin and triple seedlings was calculated using the formula.

$$\text{Percentage of twin and triple seedlings} = \frac{\text{No. of germinated seeds with twin/triple seedlings}}{\text{No. of incubated seeds}} \times 100$$

For counting the double embryos triphenyl tetrazolium chloride test (TTC test) with 0.5% TTC solution was used. The seeds of apomictic population IV (100 in each of 3 replications) were soaked for 12 hr. in water at 30° C. Each seed was spilt into two equal parts with knife, each with partial embryo. The seeds were stained with TTC solution for 6-12 hr at 30°C. The seeds with 2 to 3 red coloured stained embroys were counted and percentage was calculated using the following formula.

$$\text{Percentage of double embryos} = \frac{\text{No.of stained double embryos}}{\text{No. of tested embryos}} \times 100$$

Maximum percentage of twin and triple seedlings averaged over 3 replicates was 6.25% in apomictic population IV and negligible in apomictic populations I, II, and III. While the percentage of double embryos in apomictic population IV was 6.14% (Fig 2&3).

Variation in the distance between the twin seedling was also observed (Fig 4). It ranged from 0.5 to 2.5 cm at the point of maximum gap between twin seedlings of apomictic population IV.

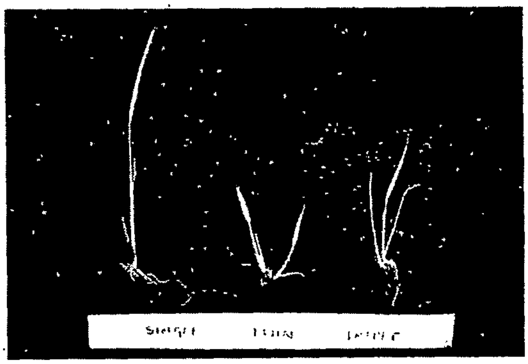
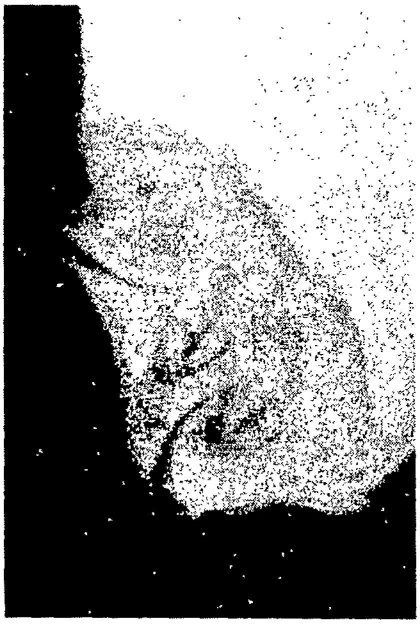


Fig 1. Germinating seeds with more than one plumule in rice apomictic population IV



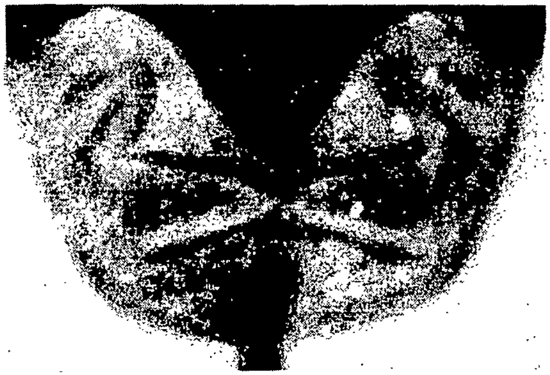


Fig 2 and 3. The presence of double embryos (Stained with tetrazolium) in rice apomictic population IV.

The double embryo test conformed to the results of germinating tests. The percentage of 6.25% of twin and triple seedlings was not significantly differing from 6.14% of double embryos in apomictic population IV. However, the observed percentage twin and triple seedlings and double embryos in rice apomictic population IV was low and frequency can be increased by methods like recurrent low irradiation of apomictic population IV as suggested by Yuan (1993) for commercial exploitation of apomictic seed in perpetuating hybrid vigour of rice hybrids.

The maximum gap between twin seedlings indicating that one of the two seedlins may be really apomictic *i.e.*, arising from non-zygotic tissue, while the other seedling was originally from the fertilized egg or zygote.

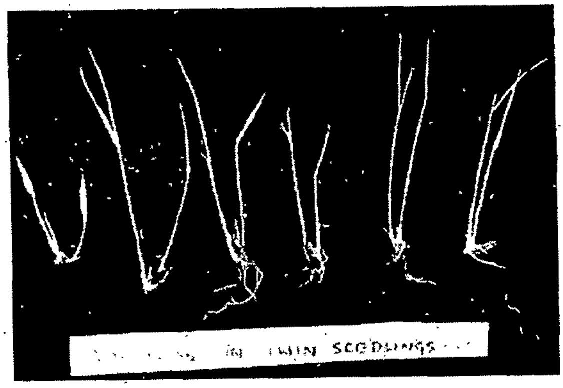


Fig 4. Variation in the distance between the twin seedlings in rice apomictic population IV.

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Research Note

Nutrient Status of Red, Black and Their Associated Soils of Tiruvuru Mandal of Krishna District of Andhra Pradesh

Key Words : Nutrient Status, Red Soil, Black Soil

The red as well as black soils of Andhra Pradesh occupy 65 and 25 per cent of the total geographical area, respectively. These soils are generally and deficient in N, P, K and some of the micronutrients. Red, black and associated soils of Tiruvuru mandal were of high potential where crops like paddy, cotton and plantation crops are grown and those soils were not characterised and evaluated for their nutrient status.

Depthwise samples were collected in six locations for evaluating nutrient status. The soil samples were processed and analysed following Jackson (1973).

The texture of the soil was sandy clay loam to clayey, the clay content increasing with depth. The bulk density varied from 1.30 to 1.62 Mg m^{-3} and showed an increasing trend with depth, which might be due to compaction of finer particles in deeper layers. The clay content and water holding capacity were significantly related (r=0.977).

The pH values were found to be between 6.5 to 8.5 (neutral to strongly alkaline). The soils were non-saline and thus do not pose any salt problem to the crops grown in these soils. The organic carbon content was low and ranges between 0.18 to 0.65 per cent. The cation exchange capacity values of the soils ranged from 4.81 to 60.15 Cmol (p^+) kg^{-1} and the cation exchange capacity values were following trend of clay content with depth. The positive correlation (r= 0.954) between cation exchange capacity and clay is highly significant. The base saturation ranged from 69.71 to 97.25 per cent. The available N was low in all pedons due to low organic carbon content (Table). The available P was low to medium because of the phosphorus fixation by kaolinitic mineral. The available K content was medium to high, which could be attributed to the presence of K bearing mineral.

According to the critical limits of Lindsay and Norvel (1978) most of the samples were fairly rich in available Cu, Mn and Zn. Fe was deficient in these soils.

Table : Chemical characteristics of the soils of Tiruvuru mandal of Krishna district of Andhra Pradesh

Profile number	Depth (m)	pH (1:2.5)	EC(1:2) dSm^{-1}	O.C. (%)	$CaCO_3$	CEC [Cmol (p+) kg^{-1}]	Exchangeable cations [Cmol(p+) kg^{-1}]				Available						
											Macro-nutrients (ppm)			Micro-nutrients (ppm)			
							Ca^{+2}	Mg^{+2}	Na^+	K^+	N	P	K	Zn	Cu	Mn	Fe
1	0.00-0.06	7.8	0.64	0.51	4.0	46.67	33.15	8.32	0.85	0.52	154	11.0	192	1.14	1.10	22.0	3.55
	0.06-0.19	8.0	0.53	0.43	4.2	50.46	35.44	10.12	1.02	0.43	126	9.0	180	1.12	0.90	18.0	3.17
	0.19-0.61	8.0	0.32	0.41	6.8	51.89	36.48	11.05	1.27	0.36	70	8.5	160	0.92	0.82	16.0	1.75
	0.61-0.82	8.1	0.24	0.36	9.2	53.60	38.08	11.63	1.42	0.28	56	7.0	144	0.86	0.76	15.0	2.20
	Below 0.82	8.2	0.24	0.36	10.1	55.70	40.11	12.21	1.53	0.21	40	6.5	128	0.77	0.74	14.0	2.00
2	0.00-0.10	6.9	0.26	0.39	-	12.24	6.92	2.66	0.61	0.52	95	4.7	122	1.50	1.94	20.4	4.20
	0.10-0.29	7.1	0.18	0.34	1.2	15.74	8.91	3.45	0.88	0.41	62	4.3	100	1.26	1.77	18.9	3.10
	Below 0.29	7.3	0.16	0.27	2.5	17.00	10.41	3.90	0.96	0.30	54	3.2	94	0.97	1.32	19.2	2.20
3	0.00-0.08	7.8	0.79	0.55	4.8	49.20	34.76	9.52	0.92	0.61	126	12.0	150	1.02	1.46	14.2	3.46
	0.08-0.29	8.0	0.81	0.46	6.4	52.66	37.19	10.73	1.12	0.50	74	10.2	138	0.92	1.22	16.4	3.20
	0.29-0.57	8.3	0.84	0.39	10.7	55.17	38.96	11.53	1.42	0.46	76	9.4	115	0.77	0.96	12.7	2.82
	0.57-0.83	8.5	0.90	0.38	12.4	57.71	40.97	13.16	1.55	0.88	52	7.2	102	0.65	0.73	10.8	2.40
	Below 0.83	8.5	1.07	0.38	13.0	60.15	41.92	14.16	1.71	0.26	42	5.5	95	0.55	0.62	9.5	2.12
4	0.00-0.12	7.0	0.18	0.40	-	4.81	1.86	0.75	0.44	0.30	82	7.2	240	0.62	1.62	24.1	7.04
	0.12-0.27	6.7	0.16	0.24	-	5.08	1.99	0.88	0.61	0.22	70	6.5	152	0.52	1.42	20.9	6.61
	0.27-0.54	6.5	0.14	0.18	-	5.50	2.13	1.09	0.80	0.18	66	4.4	180	0.44	1.21	17.2	6.32
	0.54 0.82	6.6	0.13	0.25	1.5	6.01	2.52	1.18	0.86	0.16	44	4.2	76	0.36	1.21	15.0	6.04
	Below 0.82	6.6	0.13	0.22	3.5	7.15	3.14	1.48	1.02	0.16	42	4.0	76	0.24	1.18	13.0	4.22
5	0.00-0.09	6.8	0.37	0.37	-	11.30	6.50	2.54	0.71	0.56	105	8.1	130	1.07	1.40	19.2	4.06
	0.09-0.24	7.1	0.16	0.32	2.4	13.52	7.17	3.51	0.84	0.36	89	7.4	102	0.84	1.04	18.4	3.48
	Below 0.24	7.2	0.16	0.26	4.0	15.00	8.31	3.97	0.92	0.32	64	4.4	84	0.64	0.84	18.8	3.29
6	0.00-0.08	7.7	0.60	0.65	3.2	45.12	31.67	8.56	0.77	0.60	110	9.1	180	1.21	1.05	11.2	3.35
	0.08-0.21	7.8	0.53	0.60	4.0	47.21	33.02	9.43	0.96	0.48	98	8.4	124	0.88	0.87	15.6	3.96
	0.21-0.51	8.0	0.49	0.44	8.4	50.17	35.21	10.57	1.11	0.40	75	6.2	120	0.72	0.77	15.6	3.46
	0.51-0.82	8.0	0.35	0.40	10.0	52.21	37.01	11.60	1.34	0.28	70	5.7	108	0.64	0.70	12.2	3.25
	Below 0.82	8.1	0.33	0.38	12.4	55.13	40.21	12.00	1.59	0.22	62	3.4	92	0.57	0.68	10.2	3.05

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Research Note

Efficacy of Sulphur on Growth and Yield of Sunflower (*Helianthus annuus* L.)

Key Words : Sunflower, Sulphur, Growth, Yield

Sunflower popularly known as "Surajmukhi" is a familiar oilseed crop in India. It has 45-50 per cent good quality oil and oil cakes also contain 40-44 per cent of good quality protein. Sunflower oil contains 64 per cent linoleic acid which helps in washing out cholesterol deposition in the coronary arteries of the heart.

Sulphur is now recognized as the fourth major and key plant nutrient along with nitrogen (N), phosphorus (P) and potassium (K) and plays a multiple role in the formation of oil components and sulphur containing amino-acids and protein (Patil *et al.,* 1998). So S application is highly essential in improving the yield and quality of oil seed crops. Therefore, sulphur nutrition through gypsum for the better growth and yield of sunflower was studied.

A field experiment was conducted during 2000-2001 at Vasaputhur village, Chidambaram, with sunflower crop cv.Cargill. The soil had sandy clay loam texture with pH 6.70, EC 0.70 dSm^{-1}, organic carbon 4.9 g kg^{-1} and available N, P_2O_5, K_2O and S contents were 225, 21,320 and 7.0 kg ha^{-1}, respectively. The treatments consisted of seven levels of sulphur 0, 10, 20, 30, 40, 50 and 60 kg ha^{-1} in randomized block design replicated four times. All the plots were applied with recommended dose of fertilizers @ 40:20:20 kg of N, P and K ha^{-1}.

Application of increasing levels of sulphur gradually increased the growth, yield attributes and yield of sunflower (Table).

Growth components

The plant height was significantly increased from 104.26 cm (control) to 137.87 cm at 60 kg S ha^{-1}. The application of S @ 60 kg ha^{-1} recorded the maximum leaf area index of 2.05 as against 1.10 in control on 60 DAS. The drymatter production increased as the age of the crop advanced. Among the treatments, the highest drymatter production of 4490.52 kg ha^{-1} was registered at 60 kg S ha^{-1} and with all growth components 60 kg S ha^{-1} was found to be comparable with 50 and 40 kg S ha^{-1}. The increased growth components due to sulphur application might be attributed to increased chlorophyll synthesis and enhanced photosynthetic activity of plant which in turn increased the drymatter yield (Biswas *et al.,* 1995).

Yield attributes and yield

The head diameter of 12.07, 13.29, 14.38, 15.30, 16.08, 16.15 and 16.19 cm at 90 DAS was recorded with 0,10, 20,30,40, 50 and 60 kg S ha^{-1}, respectively. The application of S @ 60 kg ha^{-1} also increased the total number of seeds head^{-1} from 617.83 (control) to 740.91 at harvest stage and highest 100 seed weight of 4.20 g as against

Table : Effect of sulphur application on growth, yield attributes and yield of sunflower

Treatments	Plant height (cm) at 60 DAS	Leaf area index at 60 DAS	Drymatter production at harvest (kg ha^{-1})	Head diameter (cm) at harvest	Total no.of seeds head^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
Control	104.26	1.10	3093.56	12.07	617.83	4.09	1263.76	1287.23
10 kg S ha^{-1}	113.82	1.32	3484.08	13.29	648.25	4.14	1406.88	1488.75
20 kg S ha^{-1}	121.65	1.55	3822.35	14.38	675.67	4.18	1536.56	1678.23
30 kg S ha^{-1}	129.48	1.78	4118.69	15.30	698.52	4.22	1654.01	1853.86
40 kg S ha^{-1}	136.56	1.99	4354.92	16.08	719.56	4.25	1756.88	1997.11
50 kg S ha^{-1}	137.42	2.03	4437.26	16.15	733.63	4.26	1831.15	2092.78
60 kg S ha^{-1}	137.87	2.05	4490.52	16.19	740.91	4.27	1901.29	2180.30
CD(P=0.05)	6.45	0.15	220.92	0.71	16.40	0.02	89.74	106.23

4.09 g in control. However, the sulphur at 60, 50 and 40 kg were not significantly different from each other in recording all yield attributes. It might be attributed due to favourable effect of sulphur on carbohydrate metabolism which led to increased translation of photosynthates resulting into formation of bold seeds (Sandeep Bansal *et al.*, 2000).

The maximum seed yield of 1901.29 kg ha^{-1} as against 1263.76 kg ha^{-1} in control and stalk yield of 2180.3 kg as against 1287.2 kg ha^{-1} (control) were recorded at 60 kg S ha^{-1} and it was comparable to application with 50 and 40 kg S ha^{-1} to adequate supply of sulphur that resulted in higher proportion of photosynthates and their translation to sink. It ultimately increased leaf area and drymatter production and higher seed and stalk yields (Tamak *et al.*, 1997).

This clearly suggested that sulphur application upto 40 kg ha^{-1} could cause a positive improvement and it will be an optimum dose in boosting the yield of sunflower.

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Research Note

Effect of Foliar Nutrition on The Nodulation and Yield of Rice Fallow Blackgram (cv. ADT 3)

Key Words : Foliar Nutrition, Nodulation, Blackgram

Blackgram (*Vigna mungo*) is the most important and esteemed grain legume (Chatterjee and Bhattacharya, 1986). Blackgram contains 21 per cent protein. Pulses not only contribute to the nutritional value of human beings, but also to soil fertility, besides providing feed for livestock in India (Asthana and Chaturvedi, 1999).

Foliar fertilization is a simple and effective method of providing nutrients to rice fallow blackgram. This is considered as an efficient and economic method of supplementing nutrient requirement (Alexander and Schroeder, 1987).

A field experiment was conducted in a sandy clay loam soil to find out the effect of foliar nutrition on the nodule number, nodule weight, nodule nitrogen and grain yield of rice fallow blackgram in randomized block design with 3 replications. The treatments included were control (T_1), foliar spray of urea @ 2 per cent on 20 and 45 DAS (T_2), foliar spray of urea @ 2 per cent on 20, 30 and 45 DAS (T_3), foliar spray of H_3PO_4 @ 2 per cent on 20 and 45 DAS (T_4), foliar spray of H_3PO_4 @ 2 per cent on 20, 30 and 45 DAS (T_5), foliar spray of DAP @ 2 per cent on 20 and 45 DAS (T_6), foliar spray of DAP @ 2 per cent on 20, 30 and 45 DAS (T_7), foliar spray of KH_2PO_4 @ 2 per cent on 20 and 45 DAS (T_8) and foliar spray of KH_2PO_4 @ 2 per cent on 20, 30 and 45 DAS (T_9). The experimental soil recorded a pH of 7.62, EC-0.63 dSm^{-1} and CEC-17.5 C mol (p$^+$) kg^{-1}. The available nitrogen, phosphorus and potassium status of the soil were 252, 16.24 and 350 kg ha^{-1}, respectively.

The nodule number plant^{-1}, nodule weight plant^{-1} and nodule nitrogen plant^{-1} were recorded at 45 DAS and grain yield was recorded at harvest stage.

Number of nodules plant^{-1}, nodule weight, nodule nitrogen and grain yield were significantly influenced by foliar application of urea, H_3PO_4, DAP and KH_2PO_4. It was also found that on the 45th DAS, treatment T_7 (foliar spray of DAP @ 2 per cent on 20, 30 and 45 DAS) recorded the highest number of nodules plant^{-1} (14.82). This was followed by treatment T_6 (13.86), T_5 (12.98) and T_4 (12.12). Treatments T_3 and T_2 recorded a value of 11.21 and 10.59, respectively and were found to be on par. Treatments T_9 and T_8 which recorded 9.72 and 9.03 nodules plant^{-1}, respectively, were found to be closely on par. The lowest number of nodules plant^{-1} (8.23) was recorded in the control (T_1).

An identical trend was observed with respect to nodule weight also. The results indicated that foliar spray of DAP @ 2 per cent on 20, 30 and 45 DAS (T_7) recorded the highest nodule weight of 91.50 mg plant^{-1} at 45th DAS. This was followed by treatment T_6 (87.80), T_5

Table : Effect of foliar nutrition on the number of nodules $plant^{-1}$, nodule weight (mg $plant^{-1}$), nodule nitrogen (mg $plant^{-1}$) and grain yield (kg ha^{-1}) of rice fallow blackgram cv. ADT 3

Treatments	Number of nodules $plant^{-1}$ on 45 DAS	Nodules weight $plant^{-1}$ on 45 DAS	Nodules N $plant^{-1}$ on 45 DAS	Grain yield kg ha^{-1}
T_1	8.23	58.10	1.05	585
T_2	10.59	71.70	1.49	789
T_3	11.21	74.80	1.54	842
T_4	12.12	79.80	1.66	912
T_5	12.98	83.90	1.78	980
T_6	13.86	87.80	1.88	1048
T_7	14.86	91.50	1:97	1120
T_8	9.03	62.90	1.25	653
T_9	9.72	65.80	1.29	711
SE_D	0.35	1.70	0.03	29.8
CD (p=0.05)	0.74	3.60	0.07	63.2

(83.90) and T_4 (79.80 mg $plant^{-1}$). Treatments T_3 and T_2 which recorded a nodule weight of 74.80 mg $plant^{-1}$ and 71.70 mg $plant^{-1}$, respectively, were found to be on par. Treatments T_9 and T_8 recorded a nodule weight of 65.80 mg $plant^{-1}$ and 62.90 mg $plant^{-1}$, respectively were found to be on par. The lowest nodule weight was recorded in control (58.10 mg $plant^{-1}$).

A similar trend was observed with respect to nodule nitrogen also. Foliar spray of DAP @ 2 per cent on 20, 30 and 45 DAS, recorded the highest nodule nitrogen (1.97 mg $plant^{-1}$), whereas the control recorded the lowest nodule nitrogen (1.05 mg $plant^{-1}$).

The data with regard to grain yield also followed an identical trend. The results indicated that the highest grain yield (1120 kg ha^{-1}) was recorded with treatment T_7. This was followed by treatment T_6 (1048 kg ha^{-1}), T_5 (980 kg ha^{-1}) and T_4 (912 kg ha^{-1}). Treatments T_3 and T_2 which recorded a grain yield of 842 and 789 kg ha^{-1}, respectively, were found to be comparable with each other. Treatments T_9 and T_8 recorded 711 kg ha^{-1} and 653 kg ha^{-1}, respectively, and were found to be closely on par. The lowest grain yield (585 kg ha^{-1}) was recorded in the control (T_1).

The results clearly revealed that foliar application of N and P through DAP @ 2 per cent on 20, 30 and 45 DAS would have enhanced the rate of growth during the peak growth period. This would have lead to the development of root nodules with higher nodule weight and nodule nitrogen compared to urea and H_3PO_4 which supplied only N or only P, respectively (Namdeo and Gupta, 1990). However, foliar spray of KH_2PO_4 recorded lesser number of root nodules and this may be attributed to the decreased activity of native rhizobium in the absence of sufficient N (Kumaran and Subramanian, 2001). Subramani and Solaimalai (2000) reported that higher number of nodules $plant^{-1}$ in blackgram might be due to more root proliferation under adequate supply of N and P.

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Research Note

Effect of Udaipur Rock Phosphate Enriched Microbial Culture, Organic and Inorganic Material on Soil Nutrient Availability of Blackgram

Key Words : Udaipur Rock Phosphate, Pressmud, Biogas Slurry, Phosphorus Solubilizing Bacteria, Elemental-S, SSP

Rock phosphate, a cheap source of phosphorus to plants can be exploited by treating them properly. Low grade rock phosphate were found effective mostly on acid soils (Narayanasamy and Biswas, 1998). Recent studies showed encouraging yield response of wheat and gram to the direct application of high grade rock phosphate on neutral to alkaline soils (Sekhar and Aery, 2001). Blackgram is an important pulse crop grown both in *kharif* and *rabi.* Being a protein rich crop, it responds well to the phosphorus application. Hence, an experiment was conducted to study the effect of Udaipur rock phosphate amended with SSP, pressmud, elemental-S, biogas slurry and enriched with microbial culture on nutrient availability of blackgram grown in a clay soil.

The soil texture was clay in texture with pH 8, EC 0.42 dSm^{-1}, O.C. 0.43%, CEC 39.79 C mole (p^+) kg^{-1} and contains 282.0, 19.5, 420 kg ha^{-1} of NPK and 2.79, 5.23, 2.99 and 0.45 ppm of Fe, Mn, Cu, Zn, respectively and rich in S, Ca and Mg.

Seven treatments of pot culture are T_1 : Udaipur rock phosphate (URP) T_2 : URP + elemental-S (1:2), T_3 : URP + pressmud (1:8), T_4 : URP + biogas slurry (1:3), T_5 : URP + phosphorus solubilising bacteria (*Pseudomonas fluorescens*), T_6 : URP + SSP (1:1), T_7 : SSP.

Ten kg of air dried, pulverised soil was taken in earthen pots and elemental-S, pressmud, biogas slurry, SSP were added on weight basis. A fertilizer recommendation (ZREAC) of 20:40:0 was followed through the basal application of rock phosphate and urea. Rock phosphate with amendments were applied ten days in advance while SSP was applied one day before sowing. Ten bold and healthy seeds of blackgram variety of LBG 648 were sown in each pot and subsequently thinned at 10 days after sowing, to allow four healthy seedlings in each pot. The experiment was conducted using a completely randomized block design with six replications of which three replications in each treatment were used at both flowering and harvest stages for soil and plant analysis by adopting standard procedures.

Application of SSP, URP+SSP, URP+pressmud and URP + elemental-S increased the availability of nitrogen, phosphorus, calcium, magnesium, sulphur, zinc, iron, manganese and copper significantly over URP alone.

Table 1 : Effect of different treatments of phosphorus on soil available nitrogen, phosphorus and potassium

	Flowering			Harvest		
Treatment	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T$_1$	294.58	20.46	540.88	471.40	19.23	488.20
T$_2$	330.72	23.59	613.56	526.66	21.70	543.56
T$_3$	338.92	24.26	628.03	537.45	21.92	551.80
T$_4$	318.37	22.64	590.60	510.85	20.84	526.76
T$_5$	306.36	21.12	578.83	498.52	20.45	514.63
T$_6$	348.92	25.16	648.06	546.76	22.43	567.00
T$_7$	361.10	26.82	662.53	566.45	23.27	584.50
SEm ±	10.48	0.85	21.71	16.86	0.71	17.26
CD (p=0.05)	31.81	2.59	65.86	51.14	2.15	52.38
CV (%)	5.53	6.31	6.17	5.58	5.75	5.54

Availability of N, P,K

The available per cent increase at flowering was 22.5, 18.4, 15.0 and 12.2 in nitrogen, 31.0, 22.9, 18.5 and 15.2 in phosphorus and 22.4, 19.8, 16.1 and 13.4 in potassium. The availability of these nutrients showed a decreasing trend at harvest (Table 1). Available nitrogen status of soil significantly improved from initial level in all the treatments both at flowering and harvest, indicating its appreciable building up due to increased mineralisation due to high microbial activity favoured through the better supply of phosphorus for proliferation, besides fixation of nitrogen (Gour, 1985). Organic manures supply both macro and micronutrients and substantial amounts of humus substances, particularly humic and fulvic acids. Organic manures also promote root growth, retain plant nutrients because of high CEC and act as slow release fertilizer thereby ensure availability of nutrients on long term basis. The incorporation of organic manures is known to influence favourably the physical, chemical, physico-chemical and biological properties of the soil and also increase available nitrogen, phosphorus and potassium in soil (More *et al.*, 1999). At harvest, available soil phosphorus status was depleted this reduction may be attributed to high requirements of P for protein synthesis and N$_2$-fixation (IITA, 1989). The increased availability of K due to SSP, rock phosphate, organic manures could be due to their synergistic effect towards N and P availability. At harvest, available soil K status was depleted. This reduction may be attributed to high requirements of K for vegetative growth and seed formation (IITA, 1989).

Availability of Ca, Mg, S

The per cent increase at flowering was 13.1, 11.4, 9.6 and 8.2 in calcium, 18.3, 15.4, 13.3 and 10.5 in magnesium and 23.7, 17.5, 15.1 and 13.1 in sulphur. The per cent increase at harvest was 11.8, 10.2, 9.08 and 7.90 in calcium 21.9, 17.1, 14.3 and 12.8 in magnesium and 20.4, 17.1, 15.5 and 13.2 in sulphur (Table 2).

Rock phosphate application has affected the availability of calcium and magnesium, which

Table 2 : Effect of different treatments of phosphorus on soil available calcium, magnesium and sulphur

	Flowering			Harvest		
Treatment	Calcium (kg ha^{-1})	Magnesium (kg ha^{-1})	Sulphur (kg ha^{-1})	Calcium (kg ha^{-1})	Magnesium (kg ha^{-1})	Sulphur (kg ha^{-1})
T_1	8416.66	3880.00	44.04	8201.33	3286.66	41.37
T_2	9113.33	4287.66	49.81	8856.66	3709.54	46.86
T_3	9226.66	4396.32	50.71	8946.42	3757.46	47.82
T_4	8786.72	4170.00	47.92	8593.30	3518.33	44.96
T_5	8620.00	3973.33	46.40	8470.00	3413.00	43.00
T_6	9383.00	4480.00	51.76	9038.33	3869.00	48.46
T_7	9525.00	4593.45	54.50	9173.33	3986.66	49.82
SEm ±	229.45	128.17	1.52	203.93	127.48	1.54
CD (p=0.05)	696.05	388.80	4.61	618.64	386.72	4.68
CV (%)	4.41	5.21	5.34	4.02	6.05	5.80

Table 3 : Effect of different treatments of phosphorus on DTPA extractable zinc, iron, manganese and copper

	Flowering				Harvest			
Treatment	Zinc (ppm)	Iron (ppm)	Manganese (ppm)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)	Copper (ppm)
T_1	0.72	3.45	6.50	3.41	0.52	3.08	5.39	3.19
T_2	0.88	3.92	7.30	3.92	0.66	3.49	6.05	3.65
T_3	0.92	3.99	7.42	4.00	0.69	3.56	6.18	3.75
T_4	0.82	3.80	7.09	3.83	0.60	3.35	5.84	3.47
T_5	0.77	3.75	6.96	3.67	0.58	3.32	5.73	3.38
T_6	0.95	4.03	7.50	4.10	0.73	3.64	6.31	3.84
T_7	0.99	4.27	7.66	4.17	0.78	3.95	6.48	3.92
SEm ±	0.03	0.13	0.21	0.14	0.03	0.11	0.19	0.12
CD (p=0.05)	0.11	0.39	0.64	0.43	0.09	0.35	0.59	0.38
CV (%)	7.26	5.80	5.08	6.35	7.12	5.77	5.64	6.03

can be attributed to the phosphate and dolomite contained in the rock phosphate (Subehia, 1998). The presence of calcium and sulphur in SSP, sulphur in elemental-S favours the availability of these nutrients through their addition. The increase in available calcium also might be due to increased root growth which solubilized calcium following the application of P. At harvest Ca, Mg, and S availability decreased with increase in drymatter which might be due to increased rate of absorption resulting in depletion of available source.

Availability of Micronutrients

The per cent increase at flowering was 37.5, 31.9, 27.7 and 22.2 in zinc, 23.7, 16.8, 15.6 and 13.6 in iron, 17.8, 15.3 14.1 and 12.3 in manganese and 22.2, 20.2, 20.2, 17.3 and 14.9 in copper. The availability of these nutrients showed a decreasing trend at harvest (Table 3).

Application of phosphorus fertilizers along with organic manures increased the availability of zinc, iron, manganese and copper due to increased reduction as reported by Nagendra Rao (1986). The increased availability of nitrogen, phosphorus, potassium, iron, manganese, copper and zinc might be due to the formation of organic legends which have lower susceptibility for adsorption, fixation and precipitation in the soil as reported by Lee (1985).

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Research Note

Effect of Water Logging and CCC on Groundnut [*Arachis hypogaea* (L.) var. TMV-2]

Key Words : Water Logging, CCC, Groundnut

The growth and yield of a plant are modulated by a number of abiotic stress factors. Among them, excess water stress *i.e.*, water logging, which occurs due to excess rainfall during late summer and monsoon, is considered as a major determinant of plant productivity.

Groundnut (*Arachis hypogaea* L.) is the premier oil seed crop of India and contributes nearly 40% of the total oil seed production (Bandyopadyay *et al.*, 2000). In the coastal sandy loams of Andhra Pradesh, groundnut is grown from July to November. Occurrence of heavy rains or cyclones in the months of September-October in this region, which is common leads to the raise of ground water table almost to the surface level and this subsequently leads to water stagnation in groundnut fields. Prolonged water logging condition prevails leads to the set back in vegetative growth of the plant and results in lower yield.

Water logging is known to inhibit shoot and root growth, dry matter accumulation, chlorosis, degradation of chlorophyll and final crop yield (Kramer, 1969). Water logging also inhibits nodulation in legumes (Sprent, 1976). Krishnamoorthy *et al.* (1981) observed that the deleterious effects of water logging on nodule number in peanut plants is partially relieved and chlorophyll content of the leaves is fully relieved by B-nine. In water logged gram, the application of CCC and B-nine was found to increase the number of nodules, total dry weight of the plant, uptake of minerals, number of pods/plant and number of seeds /pod (Krishnamoorthy *et al.*, 1983 and 1987).

Some of the deleterious effects of water logging are reported to be relieved by the application of plant hormones (Bishnoi and Krishna Murhty, 1995) and growth retardants. Thus, the objective of the study was, to determine the influence of water logging and growth retardant (CCC) on some important biometrical and biochemical parameters of groundnut.

The pot culture study was carried out at the Net House, Department of Plant Physiology, Agricultural College, Bapatla, during the summer, 2001. Four treatments consisting of T_1 - Control - plants were maintained at approximate field capacity by watering every day; T_2 - CCC (1%) - plants were treated with 100 ml aqueous solution of CCC (1%) by soil drenching at 10 DAS and maintained at field capacity thereafter; T_3- water logging - plants were subjected to water logging at 15 DAS by maintaining water table close to the soil surface for 15 days and T_4 - CCC (1%) + water logging (WL) - plants were treated with 100 ml aqueous solution of CCC (1%) as soil drench at 10 DAS and subsequently subjected to water logging after 5 days of CCC treatment

Table : Effect of water logging and growth retardant (CCC) on some growth parameters of groundnut

Treatments	Plant height (cm)	Root length (cm)	Shoot dry weight (g plant^{-1})	Root dry weight (g plant^{1})	No.of nodules per plant	Total chlorophyll content (mg/g fresh weight)
T_1 - Control	36	6.9	2.92	0.93	35	0.783
T_2- CCC (1%)	29	6.1	2.20	1.02	27	0.623
T_3- Water logging	30	5.1	1.62	0.47	9	0.453
T_4- CCC (%) + WL	33	5.8	2.07	0.71	14	0.534
	(+10)*	(+13.7)*	(+21.6)*	(+51)*	(+55.5)*	(+17.9)*
Mean	32	6.0	2.20	0.78	20.5	0.598
SEm ±	0.41	0.24	0.04	0.02	1.42	0.003
CD (p=0.05)	1.26	0.75	0.12	0.06	4.37	0.008

* Figures in parentheses are per cent increase over water logging treatment (T_3)

for 15 days. This experiment was conducted with cultivar TMV-2 in a completely randomised block design with four replications. Data on growth parameters were recorded at 10 day intreval starting from 45 DAS till harvest and data recorded on 65 DAS are presented (Table). Chlorophyll was extracted from the leaf samples using 80% acetone as grinding media and optical density readings were taken with Spectronic - 20 at 663 and 645 nm. Total chlorophyll content was estimated using the following formula:

Total chlorophyll (mg/g fresh weight) = [8.02 (OD_{663}) + 20.2 (OD_{645})] x (volume/1000) x (1/ weight).

Plant height

Plant height (cm) decreased due to application of CCC and water logging (Table) over control. But in the T_4, where CCC was applied before imposition of water logging, significantly higher plant height was recorded over water logging alone (T_3) and the increase was 10 per cent.

Root length

Root length (cm) was found to be decreased significantly due to the application of CCC and water logging over control (Table). Though there is no significant difference between the treatments, water logging (T_3) and CCC + water logging (T_4), but application of CCC before imposition of water logging helped to increase in root length by 13.7 per cent over water logging alone (T_3).

Shoot dry weight

Shoot dry weight (g plant^{-1}) was also found to be decreased due to the application of CCC and imposition of water logging over control (Table). Application of CCC + water logging found to increase the shoot dry weight significantly over water logging alone and the increment was 21.6 per cent. Krishna Moorthy *et al.* (1983 and 1987) also observed that application of CCC and B-nine increased the total dry weight in gram over water logging.

Root dry weight

Root dry weight (g plant^{-1}) increased significantly with the application of CCC alone (T_2) over control and decreased when water logging was imposed. CCC + water logging (T_4) significantly increased the root dry weight by 51 per cent over water logging alone (T_3).

Number of nodules per plant

Number of nodules per plant was less as there was no inoculation with rhizobium. It decreased significantly in all the treatments over control. Application of CCC + water logging (T_4) significantly increased the number of nodules over water logging (T_3) by 55.5 per cent. Krishna Moorthy *et al.* (1981) also noticed that in peanut plants, the effect of water logging on nodule number was partially relieved by B-nine.

Total chlorophyll content

Total chlorophyll content (mg/g fresh weight) also decreased due to application of CCC and water logging. But the application of CCC before imposition of water logging (T_4) significantly increased the total chlorophyll content over water logging alone (T_3) by 17.9 per cent. Krishna Moorthy *et al.* (1981) also ascertained that the deleterious effect of water logging on total chlorophyll content in peanut plants was fully relieved by B-nine.

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Research Note

Effect of Pulsing Treatments on Floral Keeping Quality of Cut Rose Variety Lambara

Key Words : Pulsing, Vase Life, Keeping Quality, Rose

Flower architecture/integrity is quite important, which forms the basis of varietal character influencing vase life. Bansode *et al.* (2005) and Singh *et al.* (2002). Varietal differences are there in rose varieties and such differences are also reflected in their keeping quality and therefore the rose variety Lambara was chosen for the study. Lambara Rose variety cut flowers of 45 centimeters Length, harvested at tight bud stage were subjected to combinations of 8 pulsing treatments for a duration of 24 hours at 4-6^{0}C under high relative humidity using chemicals and distilled water. Chemicals used were sucrose 3%, 8HQC 200 ppm, citric acid 300 ppm, $AISO_4$ 300 ppm and $KMNO_4$ 200 ppm. The vase life in all treatments was studied using distilled water. Completely randomized design with five replications was adopted and each replication had 5 cut flowers.

The performance of rose variety Lambara was significantly influenced by different pulsing treatments (Table). Flowers were large in diameter by pulsing in distilled water or in solutions of 3% sucrose + citric acid 300 ppm and 3% sucrose + 8HQC 200 ppm. The flower diameter reduced significantly by treating them in rest of the pulsing solutions. The petal reflection percentage was higher by pulsing with any of the chemicals tested when compared to distilled water *i.e.* 17.71 per cent followed by the treatment sucrose 3% + $KMNO_4$ 200 ppm recording 21.19 per cent. The lesser the petal reflecting percentage, the greater is the integrity of the flowers without rolling of petals. Maximum petal reflection percentage of 45.45 was recorded by subjecting the flowers to the pulsing solution comprising 3% sucrose + citric acid 300 ppm + $AISO_4$ 300 ppm followed by the treatments *viz.,* 3% sucrose + 8 HQC 200 ppm + citric acid 300 ppm, 3% sucrose + $AISO_4$ 300 ppm and 3% sucrose + 8 HQC 200 ppm + $AISO_4$ 300 ppm. The wilting percentage of flower petals/buds/bent neck was the least in distilled water treatment *i.e.*, 35.3 per cent. The wilting percentage was significantly more in all the chemical treatments. It was maximized to 68.26 per cent in 3% sucrose + citric acid 300 ppm + $AISO_4$ 300 ppm solution. The flowers absorbed large volume of 131 cc water by pulsing them with distilled water. The absorption of water was significantly reduced to 111.6 cc by pulsing flowers with a solution of 3% sucrose + 8 HQC 200 ppm + citric acid 300 ppm and to 105.6 cc with a solution of 3% sucrose + critic acid 300 ppm. Least absorption of 93.20 cc was recorded by pulsing the flowers in a solution of 3% sucrose + citric acid 300 ppm + $AISO_4$ 300 ppm. The flowers pulsed in distilled water had a maximum vase life of 8.22 days. The vase life was significantly reduced by treating the flowers with any of the chemical treatments. Minimum vase life of 4.62 days was recorded by pulsing flowers with 3% sucrose+ citric acid 300 ppm + $AISO_4$ 300 ppm. No

Table : Influence of pulsing treatments on cut flowers of rose variety Lambara

	Treatments	Diameter (cm)	*Petal reflection (percentage)	* Flower petal wilting/Budwilting/ Bentneck (percentage)	** Vase life (days)	Volume of water absorbed (cc)
T_1	3% Sucrose + 8HQC (200 ppm)	6.47	(20.43) 26.87	(48.90) 44.37	(7.63) 2.85	140.80
T_2	3% Sucrose + citric acid (300 ppm)	6.50	(21.17) 27.39	(48.10) 43.91	(7.01) 2.74	105.60
T_3	3% Sucrose + $AlSO_4$ (300 ppm)	5.34	(37.16) 37.56	(46.49) 42.99	(7.01) 2.74	116.80
T_4	3% Sucrose + 8 HQC (200 ppm) + citric acid (300 ppm)	5.66	(38.50) 38.35	(69.80) 56.73	(6.63) 2.67	111.60
T_5	3% Sucrose + 8 HQC (200 ppm) + $AlSO_4$ (300 ppm)	5.29	(33.06) 35.10	(65.06) 53.76	(6.43) 2.63	125.20
T_6	3% Sucrose + Citric acid (300 ppm) + $AlSO_4$ (300 ppm)	5.40	(50.78) 45.45	(86.28) 68.26	(4.62) 2.26	93.20
T_7	3% Sucrose + $KMN0_4$ (200 ppm)	5.77	(13.07) 21.19	(50.03) 45.02	(7.22) 2.78	117.60
T_8	Control Distilled Water	6.45	(9.25) 17.71	(33.40) 35.30	(8.22) 2.95	131.00
	SE±	0.31	0.232	0.00478	0.04	7.70
	CD (0.05)	0.65	0.50	0.1026	0.08	15.06

* ARC - Sine - T Values ** Square Root - T Values Pre-tarnsformed values in parentheses

chlorosis of leaves/browning of stems / phytotoxic symptoms was recorded after 6 days in the treatments *viz.* 3% sucrose + 8 HQC 200 ppm and 3% sucrose + $KMNO_4$ 200 ppm. Roses pulsed with distilled water indicated very fair and the roses pulsed with 3% sucrose + citric acid 300 ppm + $AlSO_4$ 300 ppm indicated as very poor. Mean laboratory temperature of 26^0 C was recorded during experimentation period.

Thus this study, evinces that some of the rose varieties can be influenced through pulsing with distilled water apart from other chemicals for improving their keeping quality.

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Research Note

"SNAC" Analysis of Cotton Production

Key Words : SNAC Analysis, Cotton Production

In India, cotton is cultivated in 9 million hectares in varied agro-climatic conditions across nine major states and with a production of 12.20 million bales (each bale 170 kg). Cotton is the major commercial crop in the state with an area of about 12.71 lakh hectares with a total production of 15.33 lakh tonnes. The state ranks 3rd in area and production, while in productivity it stands 5th in the country. The low productivity in the state mainly due to coverage of major area under rainfed conditions with traditional varieties and negligence by stake holders. The scheme under implementation *i.e.*, Integrated Cotton Development Project (ICDP) does not focus on specific gaps in cotton cultivation. Hence, the SNAC analysis on cotton cultivation is utilized to acquire proper insights into the identification of stake holders, needs, alterables and constraints. Stake holders are those groups or individuals who were directly or indirectly affected by an organization pursuit of its goals or effected due to cotton cultivation. Need implies a gap between 'what is ' the existing situation and 'what ought to be' the desirable situation and also gap between situation and objective. Alterables are traits that are shared by some persons or cotton farmers but not shared by all members of society. Constraint referred to the item of difficulty faced by cotton farmer in adoption of recommended technology. The basic assumption of SNAC analysis acknowledges that the developments or Research and Development (R&D) programmes do not have opportunities and threats. It assumes that there are stake holders who have different and varying needs and constrains and therefore the organization has to alter its strategies for planning and implementation from time to time. Keeping in view the objective was formulated to analyse the stake holders, needs, alterables and constraints (SNAC analysis) in cotton cultivation.

Exploratory research design was followed. Two mandals in Guntur district of Andhra Pradesh were selected purposively for drawing the 110 sample of the study. From each mandal 3 villages were selected randomly. The data were collected by personal interview with the help of structured interview schedule.

The data obtained from the cotton farmers regarding SNAC parameters in cotton cultivation were quantified, *i.e.*, the number of farmers who gave the particular rank of stake holders, needs, alterables and constraints. The ranks attributed for different SNAC parameters and the frequency of farmers who gave rank could be used for calculation of rank based quotient (RBQ) (Sabaratnam, 1988).

The important ten stake holders, needs, alterbales and constraints which were ranked by respondents were,

Stake holders

The important ten stake holders in cotton cultivation which were ranked top by the cotton farmers based on rank based quotient and placed in order include State Agricultural University (ANGRAU) (92.72), RARS, Lam, Guntur (88.45), Farming Community (88.27), State Department of Agriculture (SDOA) (72.90), Mahyco Hybrid Seeds, etc. (52.27), Cotton Corporation of India (CCI) (49.27), Non-Governmental Organisations (NGOs) (42.18), Farmers Training Centers (FTC) (28.4), ETV Annadata (20.00) and radio news (16.36%).

Farmers gave first rank to State Agricultural University and the least rank to Radio News because farmers mostly depend on State Agricultural University and leastly depend on radio news.

Needs

The important ten needs in cotton cultivation which were ranked in serial by the cotton farmers were seed rate and sowing (91.90), application of fertilizers as per soil and variety (86.00), critical stages of water requirement (82.72), critical stages of crop-weed competition (76.63), identification and sensitive stages of pests for easy control (56.81), identification and reclamation of problem soils (51.09), time of picking (37.45), value added products (32.27), identification of diseases and their casual organisms (19.72) and taking soil samples for analysis (15.36).

Farmers gave first rank to seed rate and sowing and least rank to soil sampling in accordance with Saibaba (1986).

Alterbales

From the result, it could be clear that, growing of hybrid seeds for high export potential, high staple length, high fibre strength, high fibre maturity (94.00), pick kapas free from debris, dried leaves, bracts during cooler times of the day (89.09), conservation of natural enemies (81.72), crop rotation with chillies/jowar/maize/soybean/pulses/sesamum/redgram (71.00), growing of resistant varieties like LPS 141, LK 861, triazophos/ endosulfan/ profenophos/ neem oil/ ethion for control of while fly (57.54). By dibbling the cotton seed in the intersecting points made by the marker reduces the weed growth as it facilitates inter-cultivation by working gorru and guntaka on all directions thereby saving labour on weed management (52.45), the regulated markets should provide requisite facilities to farmers for storage, loans, insurance against fire and theft, etc., for selling their produce at competitive prices (41.16), good quality of market information regarding prices, etc., should be made available to the farmers through mass media, newspapers (27.45), removal of cotton stubbles after last picking without opting for ratoon crop for breaking the cycles of problematic pests (19.90) and spraying of NAA 10 ppm for control of bud and boll shedding (15.63).

Farmers gave first rank for growing of hybrid seeds, least rank for spraying of NAA 10 ppm for control of bud and boll shedding. This might be due to hybrid seeds gave better yields and minimizing pesticide consumption in conformity with Sriram and Palaniswamy (1999).

Constraints

Findings show that the ten important constraints which were ranked by the respondents were, expensiveness of plant protection measures (94.09), low price to cotton at proper time (91.00), high cost of hybrid seed

(84.09), costliness of fertilizer (65.18), non-availability of labour at proper time (62.63), insufficient supply of water (49.18), health hazards due to application of insecticides/ pesticides (41.63), more labour requirement for spraying (33.09), high cost of implements (17.27) and non-availability of insecticides/ pesticides at proper time (15.18)

The farmers gave first rank to expensiveness of plant protection measures, least rank to non-availability of insecticides/ pesticides at proper time in line with More *et al.* (1998) and Katole *et al.* (1998).

The results of the study showed that the major stake holders, needs, alterables and constrains in cotton cultivation which were ranked by cotton farmers were : State Agricultural University (ANGRAU), seed rate and sowing, growing of hybrid seeds for export potential and expensivenes of plant protection measures. In brief, SNAC analysis is a modern management tool analyse stake holders, needs, alterables and constraints in cotton cultivation.

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Research Note

Assessment of Training Needs of Agricultural Officers of Sugar Factories in Andhra Pradesh

Key Words : Training Needs, Agricultural Officers, Sugar Factories

Andhra Pradesh is the 5th largest producer of sugarcane in the country. The crop is cultivated in 2.20 lakh ha with an annual production of about 72 lakh tonnes. The sugar factories employ their own extension personnel to disseminate appropriate technologies for crop production. In spite of the deployment of these technical staff, improvement in farm productivity of sugarcane is not very significant and still found low compared to the productivity levels of other states. Hence, there exists a greater scope for improving the efficiency of the extension personnel in not only the transfer of technology but also to motivate the farming community for technology adoption. Hence, study was undertaken to assess the training needs as perceived by the Agricultural Officers who serve as nodal extension staff of the sugar factories.

This study was taken up with a sample size of 36 Agricultural Officers from 17 sugar factories of Andhra Pradesh. A structured schedule developed for the study was used to assess the training needs of extension personnel in various aspects of sugarcane cultivation. A three point continuum namely greatly needed (3), somewhat needed (2) and least needed (1) was used to measure the score. The major components of sugarcane cultivation and sub-items under each of these components were ranked based on mean scores and total scores, respectively. The mean score of each major component is the average of the total scores of the sub-items included under that component.

The data collected were summarized and mean scores as well as ranks of the preferred areas presented in Table. The data revealed that 'Plant Protection' was the first preferred area of training as perceived by extension staff of the sugar factories. This was followed by fertilizer management, soil and moisture conservation, planting, ratooning, irrigation, inter-cultivation and the least preferred areas being harvesting and land preparation. Like in several other crops, plant protection is one of the important aspects of cultivation in sugarcane. This is because, sugarcane being a long duration crop, there is a scope for increased pest/disease intensity as successive life cycles of the pest/pathogen can be completed in a single crop season. Hence, the Agricultural Officers might have preferred Plant Protection as the most important training need. These findings are in accordance with the reports of Misra (1991), Jayraj Prakash (1992) and Prasad *et al.* (2000) with respect to the training needs of Agricultural Extension Officers under T& V system in Orissa, Assistant Agricultural Officers of Dakshina Kannada District of Karnataka and Village Extension Officers of Kurnool District in Andhra Pradesh, respectively. Among the various sub items, integrated pest management (IPM) was the most preferred training need. This preference might

Table : Training needs of extension staff of sugar factories

Training Area	Mean Score	Rank
Land Preparation	63.0	9
Planting	69.7	4
Soil and Moisture conservation	75.0	3
Fertilzer Application	84.25	2
Irrigation	66.0	6
Inter-cultivation	66.50	7
Plant Protection	94.66	1
Harvesting	64.33	8
Ratooning	67.33	5

be due to the growing importance for eco-friendly management practices. Improved knowledge on IPM enables the field officers to advocate the need to avoid indiscriminate use of plant protection chemicals and to popularize the environment friendly IPM with low input costs. Symptoms of damage was the second sub item preferred as they felt it necessary to upgrade their knowledge of identifying the pests/diseases so that proper control measures including the appropriate chemicals could be suggested to the farmers. Knowledge on this aspect would also enable to forewarn the farmers on occurrence of diseases and pests. Extent of damage was the other training need as it helps in recommending need based plant protection measures based on Economic Threshold Levels (ETL ' s) of pests/ diseases. Upgrading knowledge on this aspect would be of immense use in discouraging the indiscriminate use of plant protection chemicals and rationalization of inputs.

The second preferred training need of the extension staff of the sugar factories was fertilizer management. It was been well established that the quantity and time of application is important for high fertilizer use efficiency and also in determining the juice quality and sugar recovery. Further, in the light of upcoming concept of sustainable crop production systems, there has been growing awareness for rational use of inorganic fertilizers and supplementing the nutritional requirements with organics. The conjunctive use of organics and inorganic manures are observed to improve the quality of juice resulting in the recovery of good quality sugar. Hence, gaining the latest knowledge in integrated nutrient management might be preferred as an important training need by the extension staff. The other sub-item opted by them was organic farming. The concept of organic farming is gaining importance and the consumer awareness towards organic products is increasing day by day. Hence, the extension officers might have felt the need to have first hand knowledge on these fast advancing area of agriculture. It would enable the extension officers to educate the farmers on the positive effects of organic farming practices not only on value addition of the product but also in maintaining the soil health besides the market response to the organic products. Dosage of manures *i.e.* quantity, method and time of application were the other training needs identified by the extension officers as these components have direct impact on cane yields.

As per the collected data, soil and moisture conservation was the third preferred training need. Mitigating drought conditions through moisture conservation methods has been a priority in the agricultural sector, because of the continuous drought experienced in the State for the last three consecutive years. Hence, drought amelioration is of great importance in sugarcane as moisture stress adversely affects the cane quality. This might be the reason for opting the soil and moisture conservation as one of the important training need. Trash mulching was the most preferred sub-item. Though simple and effective, this operation needs skill in using the optimal quantity of mulch for better efficacy. Further, mulching is a most cost effective measure that helps not only in soil moisture conservation but also in reducing incidence of early shoot borer and weed growth.

In the order of preference, planting was the next opted area of training and varieties was the first preference. It is very essential to have in depth knowledge on varieties which enables the extension staff to give proper advice to the farming community on selection of suitable varieties for particular ecological niche. Planting of cane varieties of different maturity groups in a balanced manner ensures continuous supply of raw material to the factory that ultimately improves crushing efficiency and also higher sugar recovery. Sett treatment was the next preferred area probably due to the fact that sett borne diseases like smut, grassy shoot and scales are the most commonly occurring diseases in sugar cane. Knowledge on effective management of these diseases through sett treatment is having good practical implications. The other sub-items like seed rate, method of planning, selection of seed material were less preferred areas.

Ratooning was the next preferred training need. It has been well established that for realizing good yields in ratoon crop, cultural practices like proper manuring, stubble shaving and crop protection measures need to be taken up in time. Hence, ratooning, might have been considered as an important training need.

Among the various sub-items of irrigation, method of irrigation was the most preferred training need of the extension staff. As already mentioned earlier, availability of water for irrigation is becoming difficult day by day and is the major constraint for agriculture in most parts of the state. Hence, there has been growing demand for achieving better water use efficiency through micro irrigation techniques. In the light of this recovery it is very pertinent that the Extension personnel felt the need to be educated on latest trends in irrigation technologies for advising the farmers on effective utilization of irrigation water.

Next in the series was the inter-cultivation, time of weeding and chemical weeding was considered as the most important sub-item under this subject. Of late there has been a strong debate on the efficiency and cost effective weed management methods. Considering the growing labour demand and efficacy as well as economics, chemical weed control method is gaining popularity. On the other hand, potential benefits of organic agriculture in protecting the soil micro climate have been well realized. Hence, it is obvious that the extension personnel opted for training on various aspects of weed control, intercropping towards efficient land utilization and realizing additional income.

Lastly, as per data collected, the harvesting and land preparation were the least preferred training needs of the field staff. Although the extension personnel gave less preference to these aspects, harvesting and land preparation are key operations to be educated. Because these two operations influence the cane yields and sugar quality. Deep ploughing using implements is very essential for moisture retention especially in the deep rooted crops like sugarcane which also helps to reduce pest/ disease incidence. Harvesting the crop to ground level also influences the yield in terms of better ratoons and high sugar quality.

The findings of this study have good practical implications. The Agricultural officers of sugarcane factories are directly responsible for dissemination of appropriate production technologies to the farmers. In doing so, the extension personnel should be able to protect the farmer's interests and factory's interests as well. While the farmers are looking at low cost high production technologies, the factories are interested in efficiency improvement through getting continuous supply of raw material to the factory and higher sugar recovery. Hence, in order to shoulder these duel responsibilities and to rise up to the expectations of the stakeholders the Agricultural officers of the sugar factories should acquire in-depth and latest knowledge in various aspects of sugarcane cultivation. Hence, systematic training is an essential prerequisite for updating of knowledge and capacity building of the extension personnel. In this context, the findings of the present study have high significance as the collected data clearly enumerated the preferences and priorities of the extension personnel in undergoing training. In the light of these observations, the present study enables the trainers to design a suitable training module for Agricultural Officers of sugar factories.

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Research Note

Methodologies Adopted by the Voluntary Organizations for Rural Development

Key Words : Voluntary Organizations, Rural Development

The role of voluntary organizations reveal that no government department can be free from the out moded rules in the foreseeable future and that only autonomous bodies such as, voluntary agencies committed to rural development would be in a position to make responsibility not only for production programmes but also for eradication of hunger. Hence, the extension methodologies adopted by the voluntary organizations for rural development, were studied.

Exploratory research design was adopted for the study. Ten voluntary organizations (VO's) working for rural development were selected purposively from Guntur district of Andhra Pradesh. Two important functionaries from each selected voluntary organization were selected purposively. Thus, a total of twenty functionaries were selected. A schedule consists of a list of extension methods used by voluntary organization for promotion of rural development was prepared and subjected to the functionaries of voluntary organizations and responses were recorded on three point continuum of regularly, sometimes and never. A score of 2,1 and 0, respectively, was assigned to the response categories. Frequencies and percentages were calculated and ranks given.

Findings in Table revealed that majority of the VOs (first rank - mean score 1.80) were implementing their programmes through coordinators/community organizers as they were the right people with required knowledge and qualifications to deal the local people. Beneficiaries themselves (second rank-mean score 1.50) and village leaders (third rank- mean score 07) were the important personnel involved in controlling the activities of VOs and their low involvement is due to the lack of required skills.

It can be seen from Table that, majority of the VOs (first rank- mean score 2.00) were getting feedback quickly from the beneficiaries as they would provide first-hand information and the beneficiaries were also very cooperative in providing feedback which further improves the quality of the programmes. Feedback from staff of voluntary organization (second rank- mean score 1.50), concerned personnel after the completion of the progaramme and during the programme received third and fourth ranks with a mean scores of 1.30, 1.00 respectively. Very limited number of VOs (fifth rank- mean score 0.80) were getting feedback from the local leaders. This might be due to that the local leaders were not actively involved in all the activities of VOs.

Majority of the VOs (first rank-mean score 1.80) conducted internal evaluation as it is the less expensive method followed by external evaluation (second rank - mean score 1.10), conducting PRA (third rank - mean score 1.00), impact studies (fourth rank - mean score 0.70)

Table : Personnel involved in controlling the developmental activities of the voluntary organizations

		Extent of utilization								
		Regularly		Sometimes		Never		Total	Mean	
S.No.	Controlling of the activities	F	%	F	%	F	%	score	score	Rank
1	By Coordinators / Community organizers	18	90.00	0	0	02	10.00	36	1.80	I
2	By beneficiaries themselves	14	70.00	02	10.00	04	20.00	30	1.50	II
3	By village leaders	02	10.00	10	50.00	08	40.00	14	0.70	III
	Feed back mechanism									
1	Feed back beneficiaries	20	100.00	0	0	0	0	40	2.00	I
2	Feed back from staff of the VO	14	70.00	04	20.00	02	10.00	32	1.60	II
3	After completion of the programme	12	60.00	02	10.00	06	30.00	26	1.30	III
4	During the programme	10	50.00	0	0	10	50.00	20	1.00	IV
5	Feed back from the local leaders	02	10.00	12	60.00	06	30.00	16	0.80	V
	Evaluation of the developmental activities									
1	Internal evaluation by VO	18	90.00	0	0	02	10.00	36	1.80	I
2	External evaluation by other organizations/ funding agencies	02	10.00	18	90.00	0	0	22	1.10	II
3	Evaluation by conducting PRA	02	10.00	16	80.00	02	10.00	20	1.00	III
4	Evaluation by conducting impact studies	06	30.00	02	10.00	12	60.00	14	0.70	IV
5	Every day evaluation	04	20.00	0	0	16	80.00	08	0.40	V
	Methods of publicity and propaganda									
1	Organizing group meetings	20	100.00	0	0	0	0	40	2.00	I
2	Through folk media	08	40.00	08	40.00	04	20.00	24	1.20	II
3	Through personal interaction	10	50.00	02	10.00	08	40.00	22	1.10	III
4	Through print media	0	0.00	12	60.00	08	40.00	12	0.60	IV
5	By writing on notice boards in the villages	04	20.00	02	10.00	14	70.00	10	0.50	V
6	Through electronic media	0	0.00	04	20.00	16	80.00	14	0.20	VI
	Public relations with officials/non officials									
1	Relation with funding agencies	20	100.00	0	0	0	0	40	2.00	I
2	Relation with Central Government Officials	18	90.00	02	10.00	0	0	38	1.90	II
3	Relation with other NGO's	16	80.00	04	20.00	0	0	36	1.80	III
4	Relation with bank officials	14	70.00	06	30.00	0	0	34	1.70	IV
5	Relation with village leaders	12	60.00	08	40.00	0	0	32	1.60	V
6	Relation with State Development Officials	10	50.00	06	30.00	04	20.00	26	1.30	VI
7	Relation with Scientists of ANGRAU	04	20.00	06	30.00	10	50.00	14	0.70	VII
8	Relation with political leaders	02	10.00	04	20.00	14	70.00	08	0.40	VIII
	Types of approaches									
1	Participatory approach	18	90.00	02	10.00	0	0	38.00	1.90	I
2	Top down approach	0	0	02	10.00	18	90.00	2.00	0.10	II

and every day evaluation (fifth rank - mean score 0.40) were the methods adopted by the VOs for assessing the impact of developmental activities (Table).

Majority of the VOs (first rank-mean score 2.00) were carying their publicity and propaganda through group meetings as this method is less costly and doubts can be clarified at a time for more number of people (Table). Other methods of publicity are; utilization of folk media (second rank-mean score 1.20), personal interactions (third rank-mean score 1.10), print media (fourth rank-mean scores 0.60), notice boards (fifth rank-mean score 0.50) and very limited number of VOs were using electronic media for publicity due to non-existence of opportunity for the feedback.

It can be seen from Table that, majority of the VOs (first rank-mean score 2.00) were maintaining cordial relations with funding agencies as they have to get funds for carrying out the developmental activities. Followed by central government (second rank-mean score 1.90), other NGO'S (Third tank-mean score 1.80), bank officials (fourth rank-mean score 1.70), village leaders (fifth tank-mean score 1.60), State Developmental Officials (sixth rank-mean score 1.30). VOs were maintaining limited contacts with scientists of ANGRAU (seventh rank-mean score 0.70) as most of the VOs were less concentrating on agriculture. Very limited number of VOs (eight rank-mean score 0.40) were maintaining relations with political leaders as they might expect money from VOs.

An appraisal of Table revealed that majority of the VOs (first rank-mean score 1.90) were adopting participatory approach as it involves the commitment of people and contribution of local resources. Top down approach (second rank-mean score 0.10) was not followed as the approach resulted in failure either because of non-commitment on the part of administration or beneficiaries.

Effective methods of communication like print and electronic media were not adopted by most of the VOs and at the same time less staff strength was observed to implement everyday evaluation in most of the VOs. Hence, to adopt these two extension methods *i.e.* print and electronic media and to increase staff strength sufficient funds should be made available to the VOs.

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Research Note

Documentation and Classification of Indigenous Technical Knowledge of Tribal Farmers

Key Words : Indigenous Technical Knowledge (ITK), Tribal Farmers

India over several millenniums has been the treasure land of biological wealth, intellectual knowledge and spiritual wisdom.

Indigenous technical knowledge (ITK) is the knowledge that people in a community have developed over time, based on common experiences, tested over centuries of use endowed with the highest possible adaptability to local culture and environment (Das and Das, 2000).

This study was therefore, conducted to document the Indigenous Technical Knowledge (ITKs) including blended technologies existing in high altitude and tribal area zone of Andhra Pradesh.

The study was conducted in high altitude and tribal area zone of Andhra Pradesh comprising of Srikakulam, Vizianagaram, Visakhapatnam, East Godavari and Khammam districts. The sample of study include 5 randomly selected villages of 5 mandals from the five districts of the zone. Eighteen elderly farmers with age of more than 50 years were selected from each village by the use of simple random sampling method and included in the sample, thus a total of 90 farmers from the 5 villages was the sample of the study.

Documentation

Action research method followed by Somasundaram (1995) and Rambabu (1997) was used in this study to document the indigenous technical knowledge in agriculture in high altitude and tribal area zone of Andhra Pradesh. Ninety elderly and experienced framers were interviewed informally and secondary sources like unpublished booklets on ITK also used to document the ITK in agriculture. Besides these, the ITK were documented with the help of group discussions and field visits with an objective to dugout more ITK covering all the agricultural activities of existing crops.

Group discussion

Group discussion was organized at the end of personal informal interviews with the selected elderly and experienced farmers in all the villages. Thus, a total of five group discussion were organized one in each village.

Field Visit

Field visit was arranged at the end of the group discussion with few farmers to document the ITK directly by observation. The collected ITK by using all the methods were classified according to the crops grown and nature of the practice.

Classification of ITKs in agriculture based on nature of practice

It could be observed from the Table1, that among the 518 ITKs documented, 95 ITKS (18.34%) belong to indigenous varieties, 67 (12.93%) were related to seeds, sowing and planting 66 (12.74%) related to pest and disease

Table 1 : Classification of ITK in agriculture based on nature of practice (n=518)

S.No.	Type of ITK	Number	Percentage
1	Rain forecasting	15	2.89
2	Preparatory cultivation	23	4.44
3	Seasons	28	5.40
4	Seeds, sowing and planting	67	12.93
5	Varieties	95	18.34
6	Crop rotation and mixed cropping	52	10.04
7	Soil and water management	10	1.93
8	Inter cultivation and weed management	25	4.83
9	Manures and soil fertility management	31	5.98
10	Pest and disease management	66	12.74
11	Harvest aspects	32	6.18
12	Post harvest management	63	12.16
13	Others	11	2.12
	Total	518	100.00

Table 2 : Classification of ITKs in agriculture based on crop economic botanical classification (n=518)

S.No.	Crop economic family	Number	Percentage
1	Cereals	97	18.72
2	Millets	85	16.41
3	Pulses	57	11.00
4	Oil seeds	24	4.63
5	Vegetables	58	11.20
6	Spices and condiments	33	6.37
7	Fruits crops	38	7.33
8	Fibre crop (mesta)	17	3.28
9	Narcotics (tobacco)	14	2.70
10	General agriculture	72	13.90
11	Podu cultivation	23	4.44
	Total	518	100.00

management, 63 (12.16%) corresponding to post-harvest management and 52 (10.04%) concerned with crop rotation and mixed cropping. A minor portion of ITKs belongs to harvest aspects (6.18%), seasons (5.40%), inter-cultivation and weed management (4.83%), preparatory cultivation (4.44%), rain forecasting (2.89%), others (2.12%) and soil and water management (1.93%).

The existence of more ITKs on varieties, indicate that farmers had taken very much care to preserve indigenous germplasm. The farmers had improved the indigenous varieties by the selection and up gradation over time. The ITKs were also more on seeds, sowing and planting, pest and disease management and post harvest management. This was an indication for the farmers care on seed selection, sowing at appropriate time, effective means of preservation of germ plasm and maintaining biodiversity, Pest and disease management and storage and post-harvest care of food grains and other crops. A significant number of ITKs were in existence on crop rotation and mixed cropping systems, which clearly indicate that the farmers had tried for mixed crops in different combinations to arrive at appropriate combination of crops.

Classification of ITKs in agriculture based on crop economic botanical classification

It could be noticed from the Table 2, among the 518 ITKs documented, 97 (18.72%) belong to cereals, 85 (16.41%) belonged to millets and 72 (13.90%) related to general agriculture followed by vegetables (11.20%), pulses (11.00%), fruit crops (7.33%), spices and condiments (6.37%), oil seeds (4.63%), podu cultivation (4.44%), fibre crop (3.28%) and narcotics (2.70%). The findings indicate that more ITKs existed on cereals, millets and general agriculture. The existence of more ITKs was an indicator for the importance of crops under cultivation in the tribal area.

ITKs have been propagated and passed on through several generations, unlike the modern technologies. The present study has brought out more than 500 ITKs on various crops cultivated in the study area. These ITKs may be well documented, test verified, standardized, blended with modern technologies and recommended as alternatives.

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